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Importation, Rearing and Colonization of Parasites of the Oriental Fruit Moth

By H. W. ALLEN, Entomologist • J. K. HOLLOWAY, Assistant Entomologist and G. J. HAEUSSLER, Entomologist

Division of Fruit Insect Investigations
Bureau of Entomology and Plant Quarantine

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By H. W. Allen, *entomologist;* J. K. Holloway, *assistant entomologist;* and G. J. Haeussler, *entomologist, Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine* [2]

CONTENTS

	Page
Introduction	2
Importation of foreign parasites	3
Sources of imported material	3
Method of handling importations	4
Material imported and parasites obtained from it	7
Methods used in mass rearing and mass breeding	8
Rearing native parasites of twig-infesting larvae	8
Rearing *Macrocentrus ancylivorus*	8
Rearing *Glypta rufiscutellaris* and *Pristomerus ocellatus*	12
Rearing *Macrocentrus delicatus*	12
Breeding imported parasites attacking twig-infesting larvae	13
Breeding *Bassus diversus*	13
Breeding *Inareolata molestae* and *Orgilus longiceps*	16
Breeding *Macrocentrus thoracicus*	17
Breeding imported parasites attacking the egg of the host	18
Breeding *Trichogramma euproctidis*	18
Breeding *Phanerotoma grapholithae* and *Ascogaster quadridentatus*	18
Breeding the imported species attacking the cocoon stage	20
Breeding *Perisierola angulata*	20
Breeding *Gambrus stokesii*	21
Breeding *Phaeogenes haeussleri*	21
Parasites obtained from all sources	22
Shipment for liberation	24
Collecting and sorting parasites	24
Shipping parasites	26
Liberating the parasites	28
List of liberations by species	31
List of releases by States and counties	40
Discussion of species of parasites handled	44
Aeroplex molestae (Uchida)	45
Angitia monospilia Thomson	45
Antrocephalus stokesi (Crawford)	45
Apanteles anarsiae Faure and Alabouvette	45
Apanteles molestae Muesebeck, and others	46
Ascogaster qua driden tatus Wesmael	46
Bassus conspicuus (Wesmael)	47
Bassus diversus Muesebeck	47
Calliephialtes laspeyresiae (Uchida)	48
Cremastus flavoorbitalis (Cameron), and others	48
Elodia flavipalpis Aldrich, and others	49
Eubadizon extensor (Linnaeus)	50
Eurytoma appendigaster (Swederus)	50
Gambrus stokesii Cameron	50
Glypta rufiscutellaris Cresson	51
Hemiteles areator Gravenhorst	51
Inareolata molestae Uchida	51
Itoplectis alternans (Gravenhorst)	53
Macrocentrus ancylivorus Rohwer	53
Macrocentrus thoracicus (Nees), and others	54
Orgilus longiceps Muesebeck	55
Perisierola angulata Muesebeck	55
Perisierola, new species	56
Phaeogenes haeussleri (Uchida)	56
Phanerotoma grapholithae Muesebeck	57
Plectochorus iwatensis (Uchida)	58
Pristomerus ocellatus Cushman	58
Pristomerus vulnerator (Panzer)	58
Trichogramma euproctidis (Girault)	59
Trichogramma minutum Riley	59
Trichomma enecator (Rossi)	59
Zenillia roseanae Brauer and Bergenstamm, and others	60
Summary	60

[1] Submitted for publication, September 29, 1939.

[2] A considerable number of the liberations reported in this circular were made jointly by the Bureau of Entomology and Plant Quarantine and cooperating State agencies. These same agencies made and shipped to Moorestown, N. J., for rearing, a large part of the collections of infested peach twigs upon which the recovery observations are based. They are the Arkansas, Connecticut, Indiana, Kentucky, Maryland, Massachusetts, Michigan, New York, South Carolina, Ohio, and Virginia Agricultural Experiment Stations, the office of the State entomologist of Georgia, the Illinois Natural History Survey, the University of Missouri, the North Carolina Department of Agriculture, and the Pennsylvania Bureau of Plant Industry. Determinations of parasites received and recovered have been made by the following taxonomists of the Bureau of Entomology and Plant Quarantine: Hymenoptera, C. F. W. Muesebeck, R. A. Cushman, and A. B. Gahan; Diptera, D. G. Hall, and also the late J. M. Aldrich, curator of insects, U. S. National Museum. The writers wish also to acknowledge the valuable work of several assistants, including Earl Lott, H. J. Willard, B. E. Montgomery, and W. T. McAllister.

INTRODUCTION

Since about 1923, when the oriental fruit moth (*Grapholitha molesta* (Busck))[3] first became a formidable pest in the Eastern States, much stress has been given to the possibility of its control by parasites. One reason for this emphasis has been the lack of any generally accepted means of artificial control, and the other, the great reduction in the fruit moth's destructiveness in some sections caused by its heavy parasitization by native species. This has served to stimulate the interest of entomologists and alert growers in the possibility of increasing the effectiveness of control by work with the parasites.

The work of producing and distributing parasites of the oriental fruit moth from the laboratory of the Bureau of Entomology and

FIGURE 1.—Insectary for handling parasites of the oriental fruit moth at Moorestown, N. J.

Plant Quarantine (fig. 1), at Moorestown, N. J., has been under way since 1929, and an active part has been taken by the Bureau in the widespread colonization of the valuable indigenous parasite *Macrocentrus ancylivorus* and in the importation and liberation of a considerable number of promising species of fruit moth parasites discovered in foreign countries.

It is the purpose of this circular to present a record of the work that was done up to and including 1935, to describe briefly the outstanding characteristics and methods of handling each species, and to present the record of liberation and recovery for each county in which work has been done. It now seems probable that for some time to come work with the parasites of the oriental fruit moth will be considered an important part of the effort toward its control, and it is hoped that such a record will be useful to those engaged in such work or primarily interested in peach production.

Much work has been done in rearing *Macrocentrus ancylivorus* in its center of dominance as a fruit moth parasite and in distributing

[3] Order Lepidoptera, family Olethreutidae.

it in other sections where it did not occur. This has resulted in its widespread establishment and increase to high rates of parasitization in many important peach-growing districts widely scattered over the eastern half of the United States. Since this parasite is now established at one or more points in nearly all the States at present infested with the fruit moth, the work on *M. ancylivorus* has been greatly curtailed. Although this species has become by far the most abundant parasite of the fruit moth in the Eastern States, it was recovered in 1935 from only slightly more than half the counties, localities, and properties in which its recovery has been sought, and there is good reason to believe that it would be a valuable parasite in many orchards where it does not yet occur.

From 1931 to 1935, inclusive, a steadily increasing portion of the work of this project has been concerned with importing, rearing or breeding, sorting, shipping, and liberating foreign parasites. More than 28 species have been received and liberated, and several of these have been colonized under the conditions most favorable for their establishment. It has not yet been possible to make recovery tests from a large portion of these liberations, but from recoveries so far obtained it is definitely indicated that all work up to and including liberation has been effective, and that several species multiplied rapidly immediately following their release. This much has been determined for *Pristomerus vulnerator* from Europe and Japan, and for *Inareolata molestae*, *Bassus diversus*, *Orgilus longiceps*, and *Apanteles molestae* from Japan. Despite this, the evidence in 1935 of permanent establishment of the various foreign species is meager. *I. molestae* seemed at that time to be established in one small locality, but there is no evidence of establishment of any of the other species imported.

IMPORTATION OF FOREIGN PARASITES

Sources of Imported Material

During 1930 and 1931 a search for parasites of the oriental fruit moth was made in southeastern France and northwestern Italy. It was found that the infestation in that section was considerably more recent than that in the eastern part of the United States. Parasite species were relatively numerous, 25 being discovered, but none that were desirable for importation were abundant. Seven species, *Apanteles anarsiae*, *Ascogaster quadridentatus*, *Trichogramma euproctidis*, *Trichomma enecator*, *Zenellia roseanae*, *Arrhinomyia tragica* (Meig.) and *Actia tibialis* R. D. were successfully imported, but only in comparatively small numbers. Two species, *Ascogaster quadridentatus* and *Trichogramma euproctidis*, were increased by breeding at Moorestown. The numbers of vigorous individuals of *Apanteles anarsiae*, *Arrhinomyia tragica*, and *Actia tibialis* liberated were so small as to make the chance of their establishment slight.

In 1931 and 1932 it became possible to do a little work with the parasites of the fruit moth from Australia. The chief objective of the representative of the Bureau, R. W. Burrell, sent to Australia was to obtain parasites of the Japanese beetle, but rather limited time and funds were available for finding and forwarding supplies

of desirable fruit moth parasites. Ten parasites of the oriental fruit moth were found in Australia, and three of these, *Antrocephalus stokesi*, *Gambrus stokesii*, and *Perisierola angulata*, were successfully shipped to the United States. *A. stokesi* was found, through study of the species in the laboratory, to be a secondary as well as a primary parasite, so it was rejected as a possible introduction and all the stock was destroyed. The other two species were increased by propagation at Moorestown and liberated.

In 1932 the work of finding and shipping desirable Japanese parasites of the fruit moth was begun and, in 1935 was still in progress. About 65 species of parasites of the fruit moth have been discovered in Japan and Chosen, and 17 of these have been successfully imported into the United States and released. They are *Apantales molestae*, *A. taragamae* Vier., *Bassus conspicuus*, *B. diversus*, *Calliephialtes laspeyresiae*, *Cremastus flavoorbitalis*, *Inareolata molestae*, *Elodia flavipalpis*, *E. subfasciata* Ald., *Eubadizon extensor*, *Macrocentrus thoracicus*, *Orgilus longiceps*, *Perisierola*, n. sp., *Phaeogenes haeussleri*, *Phanerotoma grapholithae*, *Phorocera pumilio* Ald., and *Pristomerus vulnerator*. Within this area, and especially on the Asiatic mainland in Chosen, parasitization of the fruit moth is much heavier than in any other foreign region studied. Several of the species desirable for importation are as abundant there as the more important indigenous species of the United States, and have been obtained, imported, and released in large numbers. Others not plentiful in their native habitat have been increased by propagation in the United States to the point of providing comparatively large numbers for liberation. Several others have not yet been obtained, either directly from importations or by breeding at Moorestown, in numbers sufficient for satisfactory colonization.

Method of Handling Importations

The method of handling fruit moth parasites for importation has been developed to secure the highest possible degree of insurance against the accidental introduction of plant pests or undesirable hyperparsites, and also to assure the delivery of reasonably large numbers of the parasites sought, at the receiving station, in healthy vigorous condition, and at a season favorable to utilization. In certain respects this has been a separate problem for each region from which importations have been made and for each species imported, but a portion of the procedure is uniform for all importations. Since parasites have been imported from Japan over a longer period and in larger numbers than from any other region, the remarks on procedure will be confined to introductions from that country.

In the shipments of parasites from foreign ports, the factor of safety has been made exceptionally high, (1) by carefully inspecting all host material prepared for shipment to exclude chance occurrences of other insects than the fruit moth, (2) by shipping most of the parasites either as adults or as parasite cocoons freed of the living host, (3) by so handling the collecting and rearing abroad that few or no hyperparasites will be contained in the shipments, and (4) by sterilizing the shipping cases and packing materials just before packing to prevent the inclusion of undesirable insects. The record of 1935 is more or less typical of previous seasons in respect to secondary parasites and host insects reared. In a total of 31,356 parasites obtained

from importations, only 1 species (28 individuals) of a secondary parasite was reared. No host moth other than the oriental fruit moth has ever been found in importations of this insect from Japan, Europe, or Australia.

The temperature and humidity en route and speed in transit are important factors in successful importation. Most shipments now received from Japan are of relatively perishable stages, consisting of adults and cocoons of rather small parasitic Hymenoptera, that have been removed from the host cocoon before packing. These are now being transmitted in the ship's refrigerator to Seattle or San Francisco and thence at normal temperatures by air express to destination. The time en route is usually only 13 days. Parasites shipped by this method not only arrive in excellent condition but are received sufficiently early in the season to be suitable for liberation during the maximum infestation of peach twigs in a large portion of the infested territory. Parasites contained in host cocoons or in their overwintering stages, and not requiring speed in transit, are shipped under refrigeration, through the Panama Canal and the port of New York. This route, which requires about 34 days in transit, is fairly satisfactory for such material, and avoids any danger through accident to the shipment while it would be traversing the western portion of the United States not at present infested by the oriental fruit moth. Storage of parasite material while it is in transit by ship should be at a temperature of about 40° to 45° F. As a buffer against any considerable exposure to deficient humidities or excess temperatures which might be encountered en route, particularly at transfer points or in air transit, the shipments are well encased in wood and moistened sphagnum. The packages are carefully sealed to prevent the escape of any of the insects.

The packages are received at Moorestown, N. J., and opened; the parasites are sorted and then reared in a special receiving and rearing room. All cracks and joints in this room are carefully sealed. It is ventilated by fans drawing air through 60-mesh wire screening. This room is entered through a dark antechamber equipped with a trap light and with felt-padded double doors. Packing containers, all packing material, and parasite material from which emergence has been completed are sterilized by steam before being removed from the room. After being received into this room, the only active, living insects permitted to be removed from it are of those species desirable for release. All host moths and hyperparasites emerging are killed within this room before being discarded.

During 1934 and 1935 the rearing of imported material consisted mainly in obtaining emergence from unsorted aggregations of hymenopterous cocoons of parasites of the fruit moth, and their separation by species at emergence. Since more than a dozen species are usually reared from such material, sorting the active parasites is a considerable task. Separation is not attempted between closely related species of *Apanteles*, *Cremastus*, and *Elodia*, or between *Macrocentrus thoracicus* and *Eubadizon extensor*.

Material being reared for emergence is placed in special cages with cloth bottoms and tops. These cages are placed directly over pans of water (fig. 2). The emerging insects are sorted one to three times daily.

Although most hymenopterous parasites have emerged satisfacto-

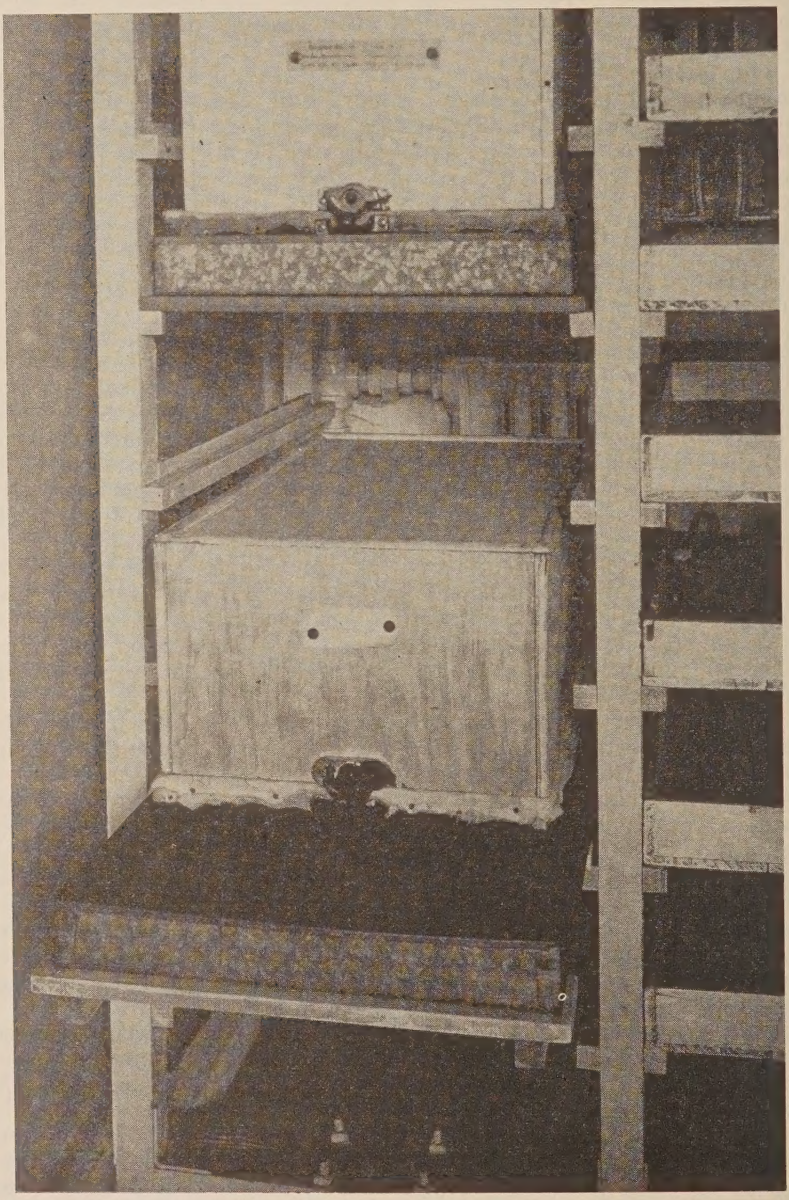

FIGURE 2.—Cage for holding imported parasites of the oriental fruit moth for emergence. One of the water pans has been drawn out to show the wire screen on which the cage rests.

rily from imported parasite cocoons, poor results were obtained from the tachinid puparia received previous to 1935. In 1935 they received special handling by which they were constantly maintained in the laboratory at a uniform, moderately high humidity, by suspending them on cloth platforms in battery jars over water, and by special packing to insure similar conditions en route. The emergence under this changed method of handling has ranged from 22 to 55 percent of the puparia received, which is much higher than during previous years.

Material Imported and Parasites Obtained From It

During the period 1930–35, 47 separate lots of parasites were imported, containing 428,292 host cocoons parasitized under field conditions, 79,155 parasite cocoons and puparia, 8,818 parasite adults, and 7,844 parasites in other stages including host cocoons inoculated in the insectary. Both parasitized and unparasitized fruit moths were present in all shipments of host cocoons. Details of the numbers shipped, relative to year, origin, and stage in which shipped, are given in table 1.

Table 1.—*Material containing parasites of the oriental fruit moth imported during the period 1930–35*

Year	Material from France and Italy					Material from Australia				
	Importations	Cocoons containing field-collected larvae	Parasite cocoons	Parasite adults	Other forms	Importations	Cocoons containing field-collected larvae	Parasite cocoons	Parasite adults	Other forms
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1930	1	3,000	427	62	0					
1931	9	147,079	1,392	228	[1] 2,262	3	0	5,411	0	0
1932						3	0	5,405	0	0
1933										
1934										
1935										
Total	10	150,079	1,819	290	2,262	6	0	10,816	0	0

Year	Material from Japan and Chosen					Material from all sources				
						1	3,000	427	62	0
1931						12	147,079	6,803	228	2,262
1932	2	0	0	2,077	0	5	0	5,405	2,077	0
1933	10	187,185	3,288	1,036	[2] 5,040	10	187,185	3,288	1,036	5,040
1934	9	79,409	18,822	733	0	9	79,409	18,822	733	0
1935	10	11,619	44,410	4,682	[3] 542	10	11,619	44,410	4,682	542
Total	31	278,213	66,520	8,528	5,582	47	428,292	79,155	8,818	7,844

[1] Includes 1,075 host cocoons parasitized with *Itoplectis alternans*, 547 parasitized with *Hemiteles areator*, and 640 host eggs parasitized with *Trichogramma euproctidis*.
[2] Includes 3,460 fruit moth cocoons from eggs parasitized with *Phanerotoma grapholithae* and 1,580 eggs parasitized with *Trichogramma minutum*.
[3] Host cocoons, each with 1 to several cocoons of *Perisierola* n. sp. attached.

The numbers of useful parasites obtained at the receiving station from the importations mentioned in table 1 are given in table 2.

Table 2 includes the totals for each species found desirable for liberation and reared in numbers considered large enough to provide

colonies of adequate size for release. It does not include data on a number of species known to be primary parasites only, which were received alive but in numbers sufficient only for identification purposes; or several other species imported in considerable numbers but found undesirable for release and destroyed at the receiving station.

TABLE 2.—*Parasites of the oriental fruit moth obtained from all importations received at Moorestown, N. J., 1930–35* [1]

Species	Origin	Living adults obtained from—				Total
		Field-collected hosts	Parasite cocoons or puparia	Shipments of adult parasites	Other material	
		Number	*Number*	*Number*	*Number*	*Number*
Apanteles anarsiae	Europe	5	18			23
Apanteles molestae and others	The Orient	34	1,039	5		1,078
Ascogaster quadridentatus	Europe	673	78			751
Bassus conspicuus	The Orient		40			40
Bassus diversus	do	189	1,154			1,343
Calliephialtes laspeyresiae	do		268	16		284
Cremastus flavoorbitalis and others	do	93	387	100		580
Elodia flavipulpis and others	do	393	891			1,284
Gambrus stokesii	Australia		110			110
Inareolata molestae	The Orient	7,655	23,373	1,179		32,207
Macrocentrus thoracicus and others	do	4,216	7,834	242		12,292
Orgilus longiceps	do	1,291	1,322			2,613
Perisierola angulata	Australia		1,578			1,578
Perisierola, n. sp.	The Orient		1,251	336		1,587
Phaeogenes haeussleri	do		180	3,854		4,034
Phanerotoma grapholithae	do	59	357	2	[2] 484	902
Pristomerus vulnerator	Europe	1,099	907	104		2,110
Pristomerus vulnerator	The Orient	87	934			1,021
Trichogramma euproctidis	Europe				[3] 640	640
Trichomma enecator	do	214				214
Zenillia roseanae and others	do	110	14			124
Total		16,118	41,735	5,838	1,124	64,815

[1] Includes only those species suitable for liberation received in numbers sufficient for liberation.
[2] From fruit moth cocoons inoculatd in the insectary.
[3] Fruit moth eggs parasitized by *Trichogramma*.

METHODS USED IN MASS REARING AND MASS BREEDING

In some cases parasites of the fruit moth can be collected within the host in the field and brought to the insectary to complete the rearing to the desired stage. This method of obtaining parasites is termed "mass rearing." In other cases it is necessary, or desirable, to breed the parasite through one or more complete generations in the insectary, reserving from each brood enough breeding stock to continue production on the scale desired. This method usually requires simultaneous breeding of the selected host. This procedure is termed "mass breeding."

REARING NATIVE PARASITES OF TWIG-INFESTING LARVAE

REARING MACROCENTRUS ANCYLIVORUS

Large numbers of the valuable indigenous parasite *Macrocentrus ancylivorus* have been reared and distributed from New Jersey. While it is feasible to breed this species in confinement, or to rear it from field-collected larvae of the twig-infesting broods of the fruit moth, the least expensive method of obtaining this parasite yet found is the rearing of field-collected larvae of the strawberry leaf roller

(*Ancylis comptana* (Froel.)) from sections in which *M. ancylivorus* is its dominant parasite.[4]

Field collecting can profitably be postponed until most of the first-generation larvae are nearly mature. This will result in the collection of a greater proportion of parasitized larvae, and will lessen the labor of caring for the material while waiting for the emergence of the parasite. Previous to the time for making the collections a considerable number of strawberry fields are located. As the infestation develops, those fields in which it is heaviest are chosen. Of those having only a moderately heavy infestation, only those fields are used in which parasitization by *Macrocentrus ancylivorus* is relatively high. This can be determined in advance by dissecting some larvae taken as samples.

Extra labor is then employed to collect the larvae. The entire infested strawberry leaf, including the stem, is taken, and the leaves are bound in bundles of 50. These bundles are set upright in metal trays, and the trays stacked in tiers in large rearing cages. The leaves are allowed to dry slowly. This process of curing is important in securing a high rate of emergence of the larvae. If this is carefully done, the outside leaves of each bundle will dry and curl, providing suitable cocooning quarters for matured larvae, while the leaves on the inside of the bundle will remain green and succulent, providing the food necessary for the immature larvae to complete their development. Constant care should be given this material during the period of curing to prevent too rapid drying, the accumulation of too much moisture, or the development of foci of destructive molds. To obtain the uniform curing of a large amount of material, wet trays or fungus spots must be located and dried out, and dry portions moistened. To facilitate the work of curing such material, the racks of trays are mounted on rubber-tired truck wheels (fig. 3) so that the material can readily be moved to any part of the cage, or quickly reversed in its position against the wall.

Each of the unit cages now used to rear this parasite has about 95 square feet of floor space, and when fully stocked will contain 130,000 strawberry leaf rollers, from which about 70,000 insects will emerge over a period of 10 days. Usually from 13,000 to 15,000 of the insects emerging are desirable parasites. The task of separating the useful parasites from this great number of active insects is by no means a small one.

Table 3 presents the results obtained from the rearing of several hundred thousand field-collected host larvae, for the purpose of obtaining adults of *Macrocentrus ancylivorus*. It indicates the relative value of the three separate broods of the strawberry leaf roller, and the first and second broods of the fruit moth infesting peach twigs as sources of this parasite.

It will be noted that the parasites emerging from the first brood of strawberry leaf rollers become available from the latter part of June to the middle of July. This period is generally satisfactory for the release of the parasite in time to attack the peak of second-brood fruit moth infestation over a large part of the infested area of the Eastern States, although all emergence after July 1 is usually too late for colonizing in advance of peak of second-brood infestation in the southern

[4] ALLEN, H. W. THE MASS PRODUCTION OF MACROCENTRUS ANCYLIVORUS, A PARASITE OF THE ORIENTAL FRUIT MOTH, AND ITS DISTRIBUTION FROM SOUTHERN NEW JERSEY. Jour. Econ. Ent. 24: 309–314, illus. 1931.

portion infested by the fruit moth, including Georgia, North Carolina, Virginia, Maryland, southern Indiana, southern Illinois, and Arkansas. Since 1931 the total insect emergence has averaged more than 500 per thousand larvae collected, and the number of *Macrocentrus*

FIGURE 3.—Movable rack loaded with leaf roller larvae in strawberry leaves in the process of curing.

ancylivorus obtained per thousand larvae collected has ranged from 113 to 203, depending on the rate of parasitization and the rate of total emergence obtained. The females have at all times considerably outnumbered the males.

TABLE 3.—*Data from the rearings of Macrocentrus ancylivorus from field-collected material*

Year	Time of collecting	Larvae collected	Period of parasite emergence	Total emergence	Emergence of *M. ancylivorus*		
					Per 1,000 larvae collected	Total emergence	Proportion of females
		Number		*Percent*	*Number*	*Percent*	*Percent*
FROM FIRST BROOD OF STRAWBERRY LEAF ROLLERS							
1930		155,300			132		
1931	June 18–30	248,712	June 28–July 28	33.8	102	30.1	
1932	June 7–16	234,500	June 20–July 14	59.7	168	28.1	58.2
1933	June 8–21	133,100	June 22–July 8	56.3	113	20.0	
1934	June 7–21	200,000	June 22–July 13	50.3	203	40.4	60.2
1935	June 17–22	40,900	June 27–July 19	49.2	122	24.9	58.3
FROM SECOND BROOD OF STRAWBERRY LEAF ROLLERS							
1931		4,000	Aug. 13–Sept. 1	33.5	178	53.0	
FROM HIBERNATING STRAWBERRY LEAF ROLLERS							
1930–31	Fall of 1930	119,000	May 6–June 1	15.8	82	52.2	58.5
1932–33	Fall of 1932	40,625	May 18–28		21		70.3
FROM FIRST BROOD OF THE ORIENTAL FRUIT MOTH							
1931		23,375			227		
FROM SECOND BROOD OF THE ORIENTAL FRUIT MOTH							
1931		16,250			425		

Observations made in 1931 indicate that *Macrocentrus ancylivorus* can be obtained at least as easily from the second-brood larvae of the strawberry leaf roller as from the first brood, but the emergence, occurring in the latter part of August, is at a period unfavorable for release against the fruit moth. In 1930–31, and again in 1932–33, hibernating strawberry leaf rollers were collected late in the fall and overwintered in confinement. It has been found rather difficult to carry this material over without heavy mortality in the host larvae. Mortality was so heavy in 1932–33 that only 21 adults of *M. ancylivorus* were obtained from each thousand leaf rollers collected. In 1930–31, however, 82 per thousand were obtained. Emergence from such material can be timed to coincide with the beginning of spring infestation, and parasites obtained at such a time are undoubtedly more valuable for release in many locations than those obtained from the first-brood leaf rollers.

The proportion of *M. ancylivorus* obtained from peach twigs infested by first- and second-brood larvae of the oriental fruit moth per thousand larvae collected is relatively high, but this advantage is offset by disadvantages that will be enumerated below.

In 1932, as a comparison of the collecting costs, 3,733 first-brood strawberry leaf rollers were collected per man-day of 8 hours, whereas only 1,564 of the hibernating leaf rollers were collected per man-day. In 1933 the cost of collecting first-brood strawberry leaf rollers, rearing the material, and sorting, packing, and shipping the parasites obtained was $28.63 per thousand parasites. In 1934, when field conditions

were more favorable, it was $13.16. These values do not include charges for equipment used or for supervision. The comparable cost for obtaining parasites from the material overwintered in 1932–33 was $118.85 per thousand parasites obtained. However, as noted above, this material overwintered in poor condition. No comparable figure on cost was obtained for the material overwintered in 1930–31, but from that material 97 parasites were produced per man-day of labor expended, as compared to only 31 per man-day for the material overwintered in 1932–33. Figures on the relative cost of obtaining parasites from strawberry leaf rollers and from larvae of the oriental fruit moth in peach twigs are not available. Data are available, however, to show that from the first brood of the fruit moth in 1931, 115 adults of *Macrocentrus ancylivorus* were obtained for each man-day of labor expended in collecting, compared to 218 for each day of labor expended in collecting second-brood fruit moth larvae in 1931, and 623 for each day of labor expended in collecting first-brood strawberry leaf rollers in 1932. This indicates that approximately three to five times as many adults of *M. ancylivorus* can be obtained with the same expenditure of labor in collecting first-brood strawberry leaf rollers as in collecting infested peach twigs. The labor cost of rearing, sorting, and shipping is about equal in each case.

REARING GLYPTA RUFISCUTELLARIS AND PRISTOMERUS OCELLATUS

By the method described for *Inareolata molestae* (p. 16) *Glypta rufiscutellaris* can be bred on the fruit moth in confinement, and both *G. rufiscutellaris* and *Pristomerus ocellatus* can be reared from field collections of twig-infesting larvae, particularly of the second brood, if taken from districts of heavy parasitization by these species. The source from which both can be obtained with the least effort for shipments of adults, however, is the common ragweed[5] when heavily infested with the small lepidopterous borer *Epiblema strenuana* (Walk.). In the vicinity of Moorestown this host is the principal known reservoir for both species, and since ragweed is usually infested with the overwintering larvae of *E. strenuana* to the degree of several larvae to a plant, large quantities of parasites are easily gathered. It is desirable to postpone gathering until late in the winter. During 1935, 4,100 adults of *G. rufiscutellaris* and several hundred of *P. ocellatus* were reared from a few bundles of ragweed gathered by the expenditure of 3 man-days of labor. Unless retarded, the *Glypta* adults will emerge 2 weeks or more before the appearance of the first brood of the fruit moth. Emergence of the adults of *P. ocellatus* occurs after the normal peak of *Glypta* emergence.

REARING MACROCENTRUS DELICATUS

Several hosts of *Macrocentrus delicatus* are abundant in certain sections. It would be possible to rear it from the midsummer brood of *Epiblema strenuana*, but larvae of this brood occur in terminal galls of ragweed at the rate of only one to a plant of average size. Collecting and trimming these galls is laborious, and after collection they must be watched carefully to prevent too rapid drying out or decomposition,

[5] ALLEN, H. W., and LOTT, EARL. EPIBLEMA STRENUANA WALK, THE HOST OF CERTAIN PARASITES OF THE ORIENTAL FRUIT MOTH, LASPEYRESIA MOLESTA BUSCK (LEPIDOPTERA). Ent. Soc. Wash. Proc. 32: 135–136. 1930.

either of which would greatly reduce the emergence of parasites. Most of the emergence of *M. delicatus* from this brood occurs later than the peak of fruit moth infestation of twigs, so from this source the parasite is not available at a desirable period for liberation.

This species was liberated in small numbers in 1929 in sections where it was already present but not abundant, and it has since been reared for exportation to other countries and for purposes not covered by the scope of the present bulletin. It may be found of value in some sections yet to be colonized.

The best source of *Macrocentrus delicatus* yet discovered is the twig-infesting larvae of the second brood of the fruit moth from sections having a heavy parasitization of this species each year. This is the case in Roane County, Tenn., and several of the counties of southern Ohio. Infested twigs are collected, trimmed, and packed in bundles of 50 in paper toweling for shipment. When received at Moorestown, they are spread evenly over a layer of green apples in open trays to allow the immature larvae to complete their development in the fruit. Fruit-moth cocoons are collected and handled as described in the technique of mass breeding of *Bassus diversus* on page 14.

Breeding Imported Parasites Attacking Twig-Infesting Larvae

BREEDING BASSUS DIVERSUS

A method of breeding in confinement has been developed that has proved satisfactory for *Bassus diversus* and has been used with some modifications with several other species.

During the period when peach twigs are succulent, usually from May to early in August, host material suitable for parasitization is obtained by infesting trimmed peach twigs with the fruit moth in units of 30 twigs to 100 host eggs. The host eggs are placed on the peach twigs in jelly glasses having about half an inch of water at the bottom. When the eggs have hatched and the young larvae have entered the twigs, they are ready for parasitization. For some species of parasites it seems more satisfactory to expose the larvae when they are very small, but with most species larvae that are at least half grown can also be used. Infested twigs in which decomposition is well advanced should be used with caution, since their exposure in cages with ovipositing parasites may result in a high mortality of the parasites, especially with delicate species such as *Macrocentrus ancylivorus*.

Parasitization may be obtained in nearly any small cage in which there is provided some ventilation, a fairly high humidity, moderate temperatures, and good light uniformly distributed. The cage shown in figure 4 has proved satisfactory. When larvae in peach twigs are exposed, the twigs are placed upright in the moist sand at the bottom of the cage, after being spaced to make all portions of the twig accessible to the parasites.

Fresh water and food for the adult parasites are constantly on hand in the parasitization cages. Sugars in several different forms have been tried as food. The most satisfactory food yet used consists of 1 part of strained honey or sugar sirup mixed with 2 parts of 1-percent agar. This mixture is melted and distributed on cardboard in small droplets. Food in this form has been acceptable to all parasites

with which it has been tried, and will keep fresh for several days and never becomes sufficiently sticky to trap the feeding insects.

Bassus diversus is active during daylight hours, so large numbers of ovipositing females are kept in one cage. In this species males are normally absent. The exposures are timed according to the numbers and apparent activity of the females. An attempt is made to regulate the exposures to obtain moderate parasitization, thus avoiding the losses due to heavy superparasitism when parasitization is too high, and the cost of breeding a large number of unparasitized hosts when it is too low. Usually sufficient moths emerge from such stock to maintain a supply of the host without supplementary breeding.

After the host larvae have been parasitized, the twigs are wrapped in moist paper toweling in units of 100 twigs, and held at 80° F.

FIGURE 4.—Cage prepared for exposing oriental fruit moth larvae in peach twigs to adults of *Bassus diversus*.

until the larvae start to wander and the twigs have been practically consumed. This material is then spread uniformly over small green apples at the rate of about 2,000 larvae to a tray of 360 square inches. As the twigs dry, the immature larvae migrate to the apples, completing their growth at normal temperatures. Only unripe fruit should be used. Small immature fruit picked at thinning time is excellent. If this is coated with an arsenical spray residue, it is advisable to wash the fruit in 1-percent hydrochloric acid and to rinse it in fresh water before using it. Previous to the issuance of mature larvae, strips of corrugated paper one-half of an inch wide are fastened with pushpins about the sides of the tray, which is about 4 inches high, and other short strips are laid over the apples (fig. 5). A large portion of the cocooning larvae spin up in these strips. The strips containing cocoons are then rolled into disks and stacked for

emergence in glass battery jars. During the emergence period the jars are opened in small sorting booths once or twice daily so that the adult parasites may be separated from the moths. The sorting booths have black curtains and a white cloth end wall faced toward strong light. They are equipped with vacuum collecting devices for sorting the emerged insects.

Succulent peach twigs cannot usually be obtained in quantities later than the early part of August. So after this time the larvae used for parasitization are allowed to hatch in units of 100 in jelly glasses, and to penetrate sliced green apples. If the apples used have been picked at thinning time, chilled before they had a chance to become heated, and kept in cold storage, they can be kept for use until the crop

FIGURE 5.—Tray containing parasitized fruit moth larvae being reared in apples.

of the following year is available. Ripe or nearly mature apples will rot before the larvae can develop and are definitely unsatisfactory. The green apples used are about an inch in diameter, and are sliced into sections about one-fourth of an inch thick. The infested sections are held together until time for exposing them to parasites, and are then separated and suspended in the parasite cage (fig. 6). After exposure they are again bound together until the overstocked fruit has been almost completely consumed. The sections are then separated and spread over fresh green apples in trays such as those previously described. A large portion of the immature larvae will migrate to the fresh fruit at points of contact, though migration from fruit is not so readily obtained as from infested twigs to fruit.

The proportion of *Bassus* obtained from propagation work is shown in table 4.

This species overwinters readily in fruit moth cocoons. The number obtained per thousand host eggs from overwintering stock has been rather low, but owing to the very rapid increase obtained in summer an adequate breeding stock is provided if only a few thousand

cocoons are overwintered. In summer breeding the number of parasites obtained per thousand host eggs is high. This ratio appears even more satisfactory when it is realized that more than 99 percent

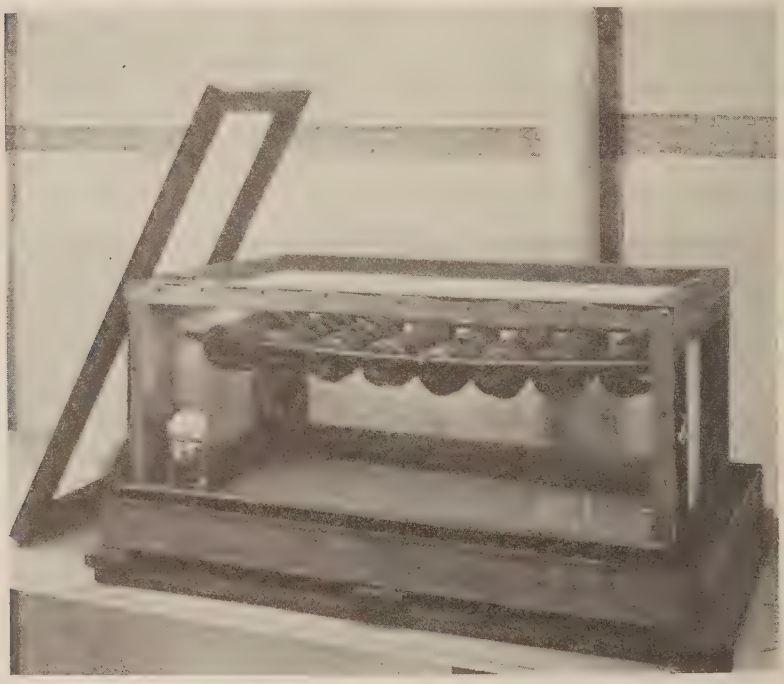

FIGURE 6.—Cage prepared for exposing oriental fruit moth larvae in sliced apple to parasites.

of the parasites obtained are parthenogenetic females producing females without fertilization.

TABLE 4.—*Results obtained from breeding Bassus diversus*

Brood	Host eggs at start of breeding	Total emergence from host eggs	Parasite emergence	
			Adults per 1,000 host eggs	Proportion of total emergence
	Number	*Percent*	*Number*	*Percent*
Overwintering stock, 1933–34	700	40.6	43	10.6
Summer broods, 1934	53,020	27.6	184	66.7
Overwintering stock, 1934–35	9,200	12.6	39	31.1
Summer broods, 1935	48,800	35.2	218	61.9

BREEDING INAREOLATA MOLESTAE AND ORGILUS LONGICEPS

Two species (*Inareolata molestae* and *Orgilus longiceps*) have been bred by the technique described for *Bassus diversus*, except that mating is necessary for the production of females. The fullest possible mating is encouraged by the admixture of the sexes both preceding

and during their confinement in the cages with the host larvae. Copulation, which appears to be normal, occurs frequently in both species so confined, but notwithstanding this the males obtained usually greatly outnumber the females. This undesirable condition is a great handicap to the propagation of these two species in confinement. It is very difficult to carry either *I. molestae* or *O. longiceps* over the winter in fruit moth cocoons since both parasites in hibernating larvae have a tendency to develop prematurely to the cocoon stage, and to die without emerging.

The results of breeding *Inareolata molestae* are shown in table 5. In summer breeding it was possible to obtain from 134 to 167 adult parasites from each 1,000 host eggs used. This is a fairly favorable production but its effectiveness is somewhat lessened by the low ratio of females obtained, which was exceptionally low in 1934. The data for overwintering material obtained for 3 seasons indicates the difficulty in carrying breeding stock through the winter in the fruit moth.

TABLE 5.—*Results obtained from breeding Inareolata molestae*

Brood	Host eggs at start of breeding	Total emergence from host eggs	Parasite emergence		
			Adults per 1,000 host eggs	Proportion of total emergence	Females
	Number	*Percent*	*Number*	*Percent*	*Percent*
Summer broods, 1932	10,550	40.2	152	37.7	24.3
Overwintering stock, 1932–33	[1] 20,827	14.3	16	11.3	37.0
Summer broods, 1933	61,500		134		32.2
Overwintering stock, 1933–34	9,550	11.3	2	1.6	64.7
Summer broods, 1934	1,110	43.8	167	38.1	1.1
Overwintering stock, 1934–35	1,900	1.8	0	0	0

[1] Estimated.

The breeding of *Orgilus* was started with a small sample late in the summer of 1933. From this, 4 females and 7 males emerged, these being 61 percent of the total emergence. In the fall of 1933 1,500 host eggs were used for overwintering stock. From this material an emergence of only 46 parasites was obtained, only 2 being males. In the summer of 1935, 4,500 eggs were used in exposures. The total emergence from this lot was at the rate of 18.3 percent, and the emergence of *Orgilus* at the rate of 51.4 percent of the total emergence, and 94 per thousand host eggs used. The percentage of females was 34.6.

BREEDING MACROCENTRUS THORACICUS

The adults of *Macrocentrus thoracicus* and also of the native *M. ancylivorus* are largely nocturnal or crepuscular in their activity. *M. thoracicus* can be bred in the manner described for *Bassus diversus*, except that the number of female parasites to an inoculating unit is reduced, and the period of exposure is lengthened. Approximately 100 host larvae to each 10 female parasites are exposed overnight in the parasitization cage, and changed each 24 hours. The breeding of *M. thoracicus* by this method is not satisfactory, however, since the males obtained always greatly outnumber the females.

Breeding Imported Parasites Attacking the Egg of the Host

BREEDING TRICHOGRAMMA EUPROCTIDIS

The parasite *Trichogramma euproctidis* was propagated continuously on bagworm eggs from October 1931 to August 1932. From the 640 of this European egg parasite of the fruit moth originally received, only breeding stock was maintained until May 1932. Mass production was then attempted, and during the period from May to July, inclusive, an estimated 1,126,000 were produced.

The use of the bagworm (*Thyridopteryx ephemeraeformis* (Haw.)) as a host for *Trichogramma euproctidis* proved satisfactory. During the winter months eggs were obtained fresh from the field at frequent intervals, and early in the spring a large stock for summer rearing work was gathered and placed in moist cold storage at about 42° F. At the end of the summer, when fresh egg clusters again became available, a large percentage of the eggs remaining in storage were still fresh and satisfactory for parasite breeding. This demonstrated that by means of summer storage bagworm eggs could be made available for parasite rearing at all times of the year.

The single factor causing most of the trouble in the use of bagworm eggs as a host of *Trichogramma* has been the tendency of the eggs to mold at high humidities and temperatures, with the consequent destruction of the parasites. This tendency was successfully counteracted by breeding at reduced incubator humidity, preferably not above 40 percent. The tendency of the larger robust adults obtained from bagworm eggs to emerge over a longer period from a given stock and to remain alive longer than adults emerging from *Sitotroga* eggs caused some inconvenience in breeding. This, however, was largely overcome by stocking each breeding chamber with a larger number of parasites and by exposing two, three, or even more cards of host eggs, successively, in the same chamber, until greatly reduced numbers of active adults under the plate indicated that the lot had spent its reproductive force. In other respects the breeding of *T. euproctidis* on bagworm eggs did not differ greatly from technique widely used in the production of *Trichogramma* from *Sitotroga* eggs.

BREEDING PHANEROTOMA GRAPHOLITHAE AND ASCOGASTER QUADRIDENTATUS

The method described below has served satisfactorily in the production of many thousands of adult parasites of *Phanerotoma grapholithae* and *Ascogaster quadridentatus* as well as of the American strain of *A. quadridentatus* common in the codling moth.

Heavy concentrations of fruit moth eggs are obtained by exposing twigs of pear, lilac, or other plant with a thick, smooth foliage, in oviposition cages densely stocked with adult moths. Such exposures are gaged to produce as nearly as possible 1,000 eggs on the leaves and stem of a twig about 6 inches long. These eggs are counted into units of about 1,000 per twig, any excess being detached by cutting away leaves, and any deficiency made up by attaching additional leaves.

These twigs, containing freshly deposited eggs, are exposed in cages (fig. 7) at the rate of 1,000 eggs to 200 adult parasites. The eggs are renewed daily. The proportion of female parasites in the cages will usually approximate 50 percent without special effort to obtain such a ratio. Any mortality among adult parasites is compensated for by the addition of newly emerged adults.

The twigs and their leaves, containing the parasitized host eggs, are removed from the cages, cut into small fragments, and strewn over

FIGURE 7.—Cage in which eggs of the oriental fruit moth are exposed to *Phanerotoma grapholithae* and *Ascogaster quadridentatus*.

the top of a layer of small green apples in rearing trays. The young larvae hatching from these fragments will spread themselves fairly uniformly in the apples, and the larvae from 2,000 host eggs can be reared without undue crowding in each tray. The mature larvae are allowed to spin up in cocoon strips and are handled beyond this point in the same manner as for *Bassus diversus*.

Data on the rate of propagation obtained in *Phanerotoma grapholithae* are presented in table 6. It will be noted that in the summer of 1934, when the best results were obtained, 177 adult parasites were secured from each 1,000 eggs exposed. In the material overwintered in 1934–35, 23 *Phanerotoma* adults were obtained per thousand eggs exposed.

TABLE 6.—*Results obtained from breeding Phanerotoma grapholithae*

Brood	Host eggs exposed	Total emergence	Parasite emergence	
			Adults per 1,000 host eggs	Proportion of total emergence
	Number	*Percent*	*Number*	*Percent*
Summer broods, 1933	125,600		96	
Overwintering stock, 1933–34	48,000	8.1	5	5.7
Summer broods, 1934	63,450	45.3	177	39.2
Overwintering stock, 1934–35	40,000	8.1	23	27.9

During 1931 and 1932, 448,067 fruit moth eggs were exposed to *Ascogaster quadridentatus*. From these an average of 127 parasites per thousand eggs exposed were obtained.

BREEDING THE IMPORTED SPECIES ATTACKING THE COCOON STAGE

BREEDING PERISIEROLA ANGULATA

The species *Perisierola angulata* was propagated continuously at Moorestown from December 1931 to October 1933. Several attempts to breed it with massed aggregations of host cocoons and ovipositing parasites were unsuccessful. So, with minor modifications, a method previously devised by R. W. Burrell for breeding these parasites in Australia was adopted. This technique involves a large amount of handling but insures a steady increase of stock.

Owing to the small size of the parasite and its strong thigmotropic reaction, small, tight cages are necessary. For this purpose a 2-dram homeopathic vial, stoppered with a cotton plug, has been used. Food and water for ovipositing adults are desirable. Small fragments of moistened rasins, one to each vial, were used and were found satisfactory. The maximum production was obtained by supplying each vial with two adult parasites of each sex and two host cocoons containing prepupae. The vials were stacked in racks (fig. 8) and examined every 4 days. At each examination parasitized cocoons, evidenced by eggs or larvae on the body of the paralyzed host ,were removed, the food renewed, and any dead parasite adults replaced. The parasitized cocoons were placed four to a vial to await emergence. Each vial was plugged with a wet cotton wad to provide moisture during the developmental period of the parasites.

At emergence time the cocoon material in the vials was worked over each day and the parasites were removed to shipping containers. Owing to the small size and active nature of adults, it was found necessary to handle them with a special collecting tool. This is a simple device consisting of a small glass nozzle about 2 inches in length, enclosed at the wide end with fine muslin, the enclosed end being then inserted in a piece of rubber tubing about 18 inches long. At the other end of the rubber tubing another short piece of glass tubing is inserted as a mouthpiece. By means of this tube adults could be quickly and certainly overtaken, sucked into the small chamber at the upper end of the nozzle, and blown into any desired receptacle.

BREEDING GAMBRUS STOKESII

In 1932 and 1933 attempts were made to breed and rear *Gambrus stokesii*, but, although mating occurred freely in confinement, the proportion of females was only sufficient to maintain the breeding stock, so the balance of the stock was finally liberated, and breeding of this species terminated.

The technique used with *Gambrus stokesii* was also worked out by R. W. Burrell in Australia. The female deposits eggs within the cocoon and beside the body of the pupa. Since several eggs are laid in one cocoon, and all unhatched ones are immediately destroyed by the first larva to hatch, the rate of propagation was increased by dislodging the eggs from the cocoons and redistributing them at the rate of one to each host pupa. This manipulation was accomplished with a fine camel's-hair brush, with which the eggs were conveyed from

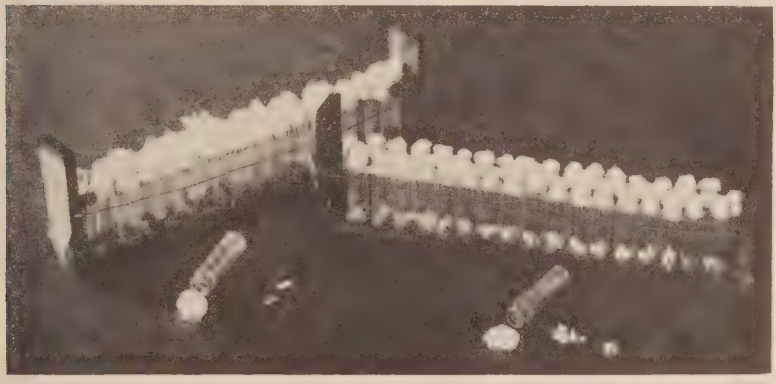

FIGURE 8.—Breeding *Perisierola angulata*. Rack at right contains vials in which cocoons of the oriental fruit moth are being exposed to parasites, the one to the left, vials containing developing parasites.

a Petri plate placed over a small square of black paper. Such parasitized pupae were enclosed in small gelatin capsules punctured for ventilation. A bit of absorbent cotton was placed in each capsule to reduce the activity of the pupae during the first few days of parasite feeding. When the parasite larva had completed its development and spun a cocoon, the cap of the gelatin capsule was removed to permit the issuance of the emerging adult.

BREEDING PHAEOGENES HAEUSSLERI

The mass rearing of *Phaeogenes haeussleri* has not been carried beyond the testing stage. In 1935, 151 were bred from stock pupae of the fruit moth without much effort. The ratio of females (54 percent) was satisfactory, and the ratio of parasites emerging to total host pupae used was 31 percent. Glass vials, 5 by 1 inch, served as satisfactory breeding chambers, and in these it was much easier to manipulate adult ovipositing females than under glass plates. Best results were were obtained by the exposure of 16 pupae daily in each vial kept stocked with 8 females.

Parasites Obtained From All Sources

The total number of useful parasites of the oriental fruit moth obtained, including those secured directly from importations, those bred at the Moorestown laboratory, and those reared from field-collected material gathered near Moorestown, is given by years in table 7. This table does not include those species found unsuitable because of hyperparasitic tendencies or received in numbers too small for release, nor does it include the considerable numbers of the 2 species of *Trichogramma* in which genus the amount of effort necessary to obtain a given number of parasites is entirely dissimilar to the other parasites enumerated. Of 390,805 parasites included in this table 326,621 were bred at Moorestown or reared from field-collected stock gathered at that locality. In addition to those shown in the table, 640 *Trichogramma euproctidis* were imported from Europe in 1931, from which 1,126,000 were bred the next year at Moorestown, and also 1,580 host eggs parasitized by *T. minutum* were received from Japan in 1933, but the attempt to breed this parasite in bagworm eggs was unsuccessful.

It will be noted that the difference between the totals produced and the totals later shown as liberated is a considerable portion of the total production. This difference includes such items as mortality in transit, mortality in storage awaiting accumulation of sufficient numbers to ship for liberation, a portion of the parasites used for propagation, losses through inexperience of some cooperating agencies in handling living insects, out-of-season production to maintain living stocks, and a number of other minor losses. It also includes considerable numbers shipped to other stations desiring to breed or experiment with them.

In addition to the parasites listed in table 7, large numbers of strawberry leaf rollers in strawberry leaves and oriental fruit moth larvae in peach twigs have been collected in the vicinity of Moorestown and shipped to various State agencies for the rearing or breeding of *Macrocentrus ancylivorus*. The cost of labor and other incidental expenses incurred in making these collections have been, for the most part, met by the State agencies or grower associations primarily interested in the work. Supervision and use of equipment have been provided by this project. A summary of this work given in table 8 shows that from 1930 to 1935, inclusive, 539,870 field-collected larvae and 20,600 adults of the strawberry leaf roller, and 130,391 field-collected larvae of the oriental fruit moth were shipped from the Moorestown laboratory. The leaf roller adults were shipped to the New York (State) Agricultural Experiment Station to be used in the mass breeding of *M. ancylivorus*.

TABLE 7.—*Total numbers of oriental fruit moth parasites obtained from importations, mass breeding, and rearing at Moorestown, N. J., 1929-35* [1]

	1929	1930		1931		1932		1933		1934		1935		1929 to 1935		Total
	Produced at Moorestown	From importations	Produced at Moorestown	From importations	Produced at Moorestown	From importations	Produced at Moorestown	From importations	Produced at Moorestown	From importations	Produced at Moorestown	From importations	Produced at Moorestown	From importations	Produced at Moorestown	
Species imported from France and Italy:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Apanteles anarsiae				23										23		23
Ascogaster quadridentatus		106		645	49, 204		7, 625							751	56, 829	57, 580
Eubadizon extensor				9										9		9
Pristomerus vulnerator		224		1, 886	1									2, 110	1	2, 111
Trichomma enecator				214										214		214
Zenillia roseanae and others		9		115										124		124
Total		339		2, 892	49, 205		7, 625							3, 231	56, 830	60, 061
Species imported from Australia:																
Gambrus stokesii						110			640					110	640	750
Perisierola angulata				1, 578			18, 024		14, 801					1, 578	32, 825	34, 403
Total				1, 578		110	18, 024		15, 441					1, 688	33, 465	35, 153
Species imported from Japan and Chosen:																
Apanteles molestae and others								250		275		553		1, 078		1, 078
Bassus conspicuus										34		6		40		40
Bassus diversus								80	1	366	9, 791	897	10, 986	1, 343	20, 778	22, 121
Calliephialtes laspeyresiae								134	54	127		23		284	54	338
Cremastus flavoorbitalis and others						100		87		94		299		580		580
Elodia flavipalpis and others								213		295		776		1, 284		1, 284
Inareolata molestae						407	2, 289	8, 906	8, 599	7, 481	202	15, 413		32, 207	11, 090	43, 297
Macrocentrus thoracicus and others						68	364	2, 915	4, 606	3, 273	836	6, 036	192	12, 292	5, 998	18, 290
Orgilus longiceps								550	11	808	2	1, 255	425	2, 613	438	3, 051
Perisierola sp.												1, 587		1, 587		1, 587
Phaeogenes haeussleri								196		256		3, 582	151	4, 034	151	4, 185
Phanerotoma grapholithae								614	12, 373	53	11, 479	235	904	902	24, 756	25, 658
Pristomerus vulnerator								70		257		694		1, 021		1, 021
Total						575	2, 653	14, 015	25, 644	13, 319	22, 310	31, 356	12, 658	59, 265	63, 265	122, 530
Indigenous species:																
Glypta rufiscutellaris					1, 700				210				680		2, 590	2, 590
Macrocentrus ancylivorus	5, 891		42, 267		48, 035		39, 407		5, 881		22, 018		5, 007		168, 506	168, 506
Pristomerus ocellatus					1, 965										1, 965	1, 965
Total	5, 891		42, 267		51, 700		39, 407		6, 091		22, 018		5, 687		173, 061	173, 061
Grand total	5, 891	339	42, 267	4, 470	100, 905	685	67, 709	14, 015	47, 176	13, 319	44, 328	31, 356	18, 345	64, 184	326, 621	390, 805

[1] This does not include the importation or breeding of *Trichogramma minutum* or *T. euproctidis*.

TABLE 8.—*Host material obtained and shipped to cooperating State agencies from Moorestown, 1930–33*

Year	State receiving shipment	Strawberry leaf roller—		Oriental fruit moth larvae
		Larvae	Adults	
		Number	*Number*	*Number*
1930	Georgia	9,350		3,925
	Illinois	44,650		5,725
	Indiana	26,600		13,741
	Ohio	75,350		6,475
	South Carolina	78,320		7,700
1931	Connecticut	122,400		67,375
	Georgia	14,950		7,000
	Kentucky	10,900		3,000
	Massachusetts	19,400		3,875
	New York	75,650		11,575
	South Carolina	47,800		
1932	New York	4,500		
1933	do		10,600	
1934	do		10,000	
1935	do	10,000		
Total		539,870	20,600	130,391

SHIPMENT FOR LIBERATION

Collecting and Sorting Parasites

When emergence occurs the parasites are sorted from the emerging host and miscellaneous insects and are counted and assembled in suitable units for shipping and liberation. If males tend to emerge before females and can be readily separated from them, some of the males are withheld for mating with the later emerging females.

In the case of large aggregations of field-collected material, the emergence takes place in the large rearing cages, and the sorting is done there. It has been found that a ceiling 6½ feet high is easy to work under, and yet not too high for collecting insects gathered thereon. One wall, well removed from the exit and from the tiers of trays holding the insects being reared, is of white muslin. The others are of heavy black cloth. This construction serves to spread the insects fairly uniformly over the white wall, where they can be readily sorted. All overlapping cloth joints are tacked and sealed with cloth strips, 2 inches wide, shellacked over the joints. This type of joint is tight and easy to work over, a point worth consideration when several thousands insects are to be picked from the walls each day.

In collecting the insects, host moths and miscellaneous insects are removed first. It is then easier to remove the parasites without including undesirable insects. A vacuum collecting apparatus is used. Host moths are collected in a large celluloid cone and are either used in breeding additional host stock or destroyed. After the host and other miscellaneous emergences have been removed, the cone is removed and an adaptor attached. By means of this the parasites are then collected into cloth-bottom vials to the number of 40 to each vial. The vacuum pressure for collecting parasites is always reduced, by rheostat control of the electric current, to a point barely sufficient to lift them from the cloth. Loaded vials are stacked in trays and placed in cold storage until the parasites are immobilized. They are then removed and inspected for accidental inclusions. If any are found, they are readily removed with a camel's hair brush.

The parasites are then blown into a shipping cage through a suitable opening in the top of the cage (fig. 9). In assembling parasites from

FIGURE 9.—Loading oriental fruit moth parasites into shipping cages.

FIGURE 10.—Sorting oriental fruit moth parasites at a small collecting booth.

mass breeding work the procedure is the same, except that emergence takes place in glass battery jars. The jars are opened in a small cloth-walled booth, from the walls of which the parasites are sorted from the hosts (fig. 10).

Shipping Parasites

The shipping unit now used for most fruit moth parasites is a small wooden box 3¾ inches square and 7¾ inches high, a size that permits 12 units to be packed in 1 refrigerated tub without loss of space. Each unit is large enough to hold several hundred adult parasites without crowding. Its sides, top, and bottom are of ⅜-inch pine impregnated with paraffin. The back and front are covered with white muslin, tacked and shellacked to the wood. The front is a slide that can be removed to release the parasites. A shipping box prepared for receiving parasites (fig. 11) includes a 2-dram homeopathic vial,

Figure 11.—Shipping container for oriental fruit moth parasites showing arrangement of the food, water, and excelsior.

holding a tightly fitting roll of dental absorbent cotton saturated with fresh water, and a small block of sugar. These are held in place by strings passing through small holes drilled in the sides of the box. A small bit of nonresinous excelsior is added to increase the "roosting space" in the container.

In the distribution of fruit moth parasites there is encountered the problem of placing delicate insects in widely scattered orchards, often several hundred miles from the rearing station, with as little loss of vitality as possible. The stage customarily colonized is the adult. At the time when most of the shipments are made, the highest midsummer temperatures are being experienced. Adult parasites are usually very active at such times, and their activity is frequently in-

creased still more by confinement with large numbers of their kind in the limited space of a shipping container. Under conditions of excessive heat, crowded confinement, and sometimes reduced humidity,

FIGURE 12.—Packing unit shipping cages of oriental fruit moth parasites into an iced shipping tub.

their vitality would soon be exhausted, and a high mortality would result.

By providing a proper combination of cold, darkness, and humidity, activity can be greatly reduced even to the point of relative immobility, so that the parasites can be transported great distances with little loss of vitality. For several years it has been found that the

shipment of parasites in refrigerated ice-cream tubs (fig. 12) by railway express is satisfactory to points as far west as the Mississippi River and south to Georgia.[6] These tubs are packed with a mixture of cracked ice and sawdust, which has been found to provide adequate cooling for from 40 to 60 hours. At the temperature of from 40° to 60° F. obtained, there is little loss of vitality and the average mortality is under 5 percent.

For the transport of small units, or shipments requiring more than 2½ days in transit by railway express, air express has been frequently

FIGURE 13.—A package of oriental fruit moth parasites prepared for air-express shipment.

used. Packages prepared for air transit are not refrigerated, but are wrapped in a thick covering of moistened absorbent cotton and corrugated paper (fig. 13). The lack of refrigeration is compensated for by increased speed of transit. It is now possible to ship parasites to any important airport in the United States within 30 hours. Frequently such unrefrigerated packages have been shipped by airplane to the airport nearest their destination and transmitted by railway express from there. Where connections are good and the total time in transit of these unrefrigerated packages has been under 30 hours, the results have been excellent.

LIBERATING THE PARASITES

A summary of all liberations made from 1929 to 1935, inclusive, is given in table 9. One thousand and ninety-three separate liberations were made, including 13 liberations of 570,300 *Trichogramma euproctidis* and 1,080 liberations of 308,414 other parasites. Most

[6] HOLLOWAY, J.K. SHIPPING ADULT INSECT PARASITES IN REFRIGERATED CONTAINERS. Jour. Econ. Ent. 26: 280-282, illus. 1933.

of these liberations were in orchards infested with the fruit moth and in sections in which the species released was not known to occur. Twenty-four species are listed, but several other species not readily separated from some of those listed were included in relatively small numbers in liberations. Since 1933 the liberations of species imported from Japan and Chosen have exceeded those of the native *Macrocentrus ancylivorus*.

It will be noted that the average number of parasites in a liberation ranges widely, from 8 for *Apanteles anarsiae* to 695 for *Phaeogenes haeussleri* and 43,869 for *Trichogramma euproctidis*. Very little

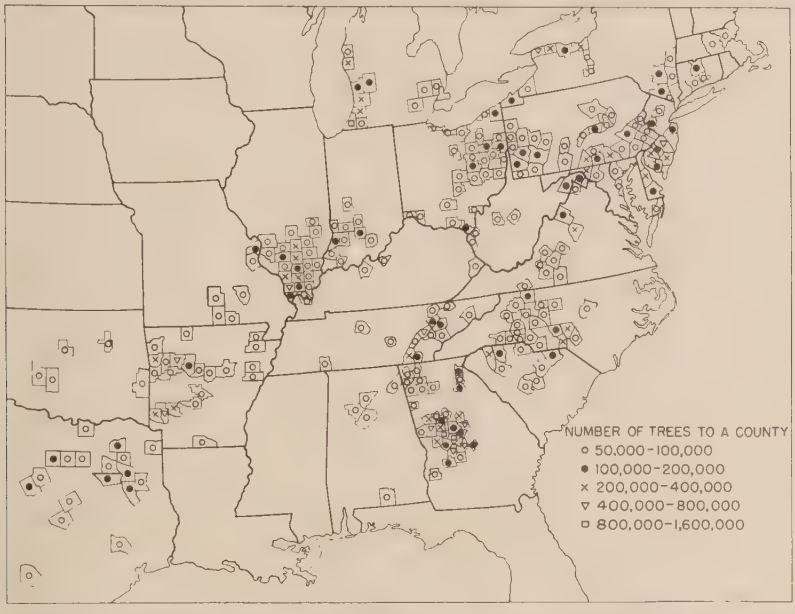

FIGURE 14.—Counties east of the Rocky Mountains having 50,000 or more peach trees.

information has been obtained on the most desirable number to release at a single time under the different conditions encountered. It is probable that many releases were too small. This is a condition, more or less unavoidable, resulting from the small numbers emerging during any one period. It is thought that releases of 200 or more should be satisfactory if other conditions are favorable. For 11 of the species listed, the average number released exceeds this number.

The present known occurrences of the oriental fruit moth in the United States indicate that it has spread nearly to the limits of peach culture east of the Plains and the Southwestern States. This is a very extensive area, but peach culture is important in only a relatively small portion of it. Since the problem of distributing parasites has been rather closely related to the distribution of the principal peach-growing districts in the eastern half of the United States, a map is presented in figure 14 to show all counties within that area having 50,000 peach trees or more, by the census of 1930, and the relative standing of such counties as to the number of peach trees reported.

TABLE 9.—*Liberation of parasites of the oriental fruit moth, 1929–35, showing the numbers of liberations and of individuals released of each species each year*

Parasites	1929		1930		1931		1932		1933		1934		1935		1929–1935		Average parasites per liberation
	Liberations	Parasites released	Liberations	Parasites released	Liberations	Parasites released	Liberations	Parasites released	Liberations	Parasites released	Liberations	Parasites released	Liberations	Parasites released	Liberations	Parasites released	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Apanteles anarsiae					1	8									1	8	8
Apanteles molestae and others									2	191	3	135	5	326	10	652	65
Ascogaster quadridentatus					78	38,839	13	5,918							91	44,757	492
Bassus conspicuus											2	29			2	29	14
Bassus diversus									2	78	68	8,797	21	10,812	91	19,687	216
Calliephialtes laspeyresiae											1	123	1	23	2	146	73
Cremastus flavoorbitalis and others							1	72	2	83	3	85	5	280	11	520	47
Elodia flavipalpis and others									2	143	4	210	6	802	12	1,155	96
Eubadizon extensor					1	6							2	109	3	115	38
Gambrus stokesii									2	91					2	91	45
Glypta rufiscutellaris					4	1,179			1	210			2	680	7	2,069	296
Inareolata molestae							3	985	87	13,808	34	6,605	27	14,660	151	36,058	239
Macrocentrus ancylivorus	5	2,400	72	23,104	100	39,346	132	38,504	27	5,810	43	16,075	8	4,457	387	129,696	335
Macrocentrus thoracicus and others									22	5,998	18	3,701	12	5,146	52	14,845	285
Orgilus longiceps									4	422	5	640	7	1,115	16	2,177	136
Perisierola angulata							28	13,414	48	12,186					76	25,600	337
Perisierola n. sp. (from Japan)													3	1,132	3	1,132	377
Phaeogenes haeussleri											2	200	4	3,972	6	4,172	695
Phanerotoma graphollthae									98	11,074	29	8,724	4	794	131	20,592	157
Pristomerus ocellatus					4	1,710									4	1,710	427
Pristomerus vulnerator			1	193	4	1,757			2	44	4	198	6	714	17	2,906	171
Trichomma enecator					2	205									2	205	102
Zenillia roseanae and others			1	5	2	87									3	92	31
Total	5	2,400	74	23,302	196	83,137	177	58,893	299	50,138	216	45,522	113	45,022	1,080	308,414	286
Trichogramma euproctidis							13	570,300							13	570,300	43,869

Liberations as a whole have been restricted to important peach-growing areas. The distribution of *Macrocentrus ancylivorus* has been more widespread and extensive than that of any other species. Among the imported species, much more extensive distributions have been made of oriental species than of those from either Europe or Australia. The peach-growing areas east of the Alleghenies, and western New York, have been much more extensively colonized with imported species than the infested districts farther west.

List of Liberations by Species

The following list is a record of the parasite liberations in which the Bureau of Entomolgy and Plant Quarantine participated. Many of the releases listed were made cooperatively with State agencies, but the list does not include additional releases made by State agencies from material reared by them. A considerable amount of such work was done in the case of *Macrocentrus ancylivorus* in Massachusetts, Connecticut, New York, South Carolina, Georgia, Ohio, and Indiana. This list also does not include numerous liberations made by the Connecticut Agricultural Experiment Station in Connecticut of the imported species *Ascogaster quadridentatus*, *Bassus diversus*, *Inareolata molestae*, *Perisierola angulata*, and *Trichogramma euproctidis* bred by them from stock furnished by the Moorestown laboratory.

There is recorded in this list the States, counties, and towns in which liberations were made, the year of release, and the number released in each colony. For instance, under *Apanteles molestae* it is indicated that in Burlington County, N. J., 1 lot of 139 was liberated in 1933 at Moorestown, and 1 of 111 in 1935 at Parry.

Apanteles anarsiae

New Jersey:
Burlington: 1931, Moorestown (8).

Apanteles molestae

(Included with this species are an undetermined number of *Apanteles taragamae* and *Apanteles* sp.)
Connecticut:
Hartford: 1934, Southington (91).
New York:
Monroe: 1933, West Webster (52). Niagara: 1935, Olcott (40). Wayne: 1935, Williamson (29).
New Jersey:
Burlington: 1933, Moorestown (139); 1935, Parry (111).
Pennsylvania:
Adams: 1935, Biglerville (127). Franklin: 1935, Waynesboro (19).
Maryland:
Washington: 1934, Smithsburg (40).
Michigan:
Berrien: 1934, Eau Claire (4).

Ascogaster quadridentatus

Connecticut:
New Haven: 1932, Cheshire (470).
New York:
Niagara: 1932, Olcottt (492). Orange: 1931, Middle Hope (500). Rockland: 1931, Monsey (500), Spring Valley (500).
New Jersey:
Atlantic: 1931, Hammonton (500) (500) (500), Landisville (500). Burlington: 1931, 54 colonies of 26,847 parasites were distributed into all sections

of the county. CAMDEN: 1931, Ellisburg (500) (492), Elm (500), Haddonfield (500) (500), West of Marlton (500) (500), Merchantville (500) (500), Pennsauken (500) (500). GLOUCESTER: 1931, Asbury (500), Glassboro (500), Hurffville (500), Mullica Hill (500), Sewell (500), Thorofare (500).

DELAWARE:

KENT: 1932, Cheswold (498). SUSSEX: 1932, Bridgeville (493).

TENNESSEE:

ROANE: 1932, Kingston (474) (475) (353) (488) (448) (450) (344) (491).

OHIO:

OTTAWA: 1932, Gypsum (442).

Bassus conspicuus

OHIO:

SUMMIT: 1934, West Richfield (6).

MICHIGAN:

BERRIEN: 1934, Eau Claire (23).

Bassus diversus

CONNECTICUT:

FAIRFIELD: 1934, Wilton (99). HARTFORD: 1934, Farmington (100), Glastonbury (150) (149), Southington (100). MIDDLESEX: 1934, Middlefield (148). NEW HAVEN: 1934, Cheshire (100), Guilford (145), Hamden (150).

NEW YORK:

DUTCHESS: 1934, Annandale-on-Hudson (150), Red Hook (149), Rock City (146). MONROE: 1934, Morton (97), Rochester (147), Webster (150); 1935, Irondquist (877), Morton (880). NIAGARA: 1934, Barker (100), Lockport (99), Wilson (100); 1935, Somerset (829). ORANGE: 1934, Newburgh (150) (199); 1935, Newburgh (393). ORLEANS: 1934, Eagle Harbor (100), Kenyonville (93), Knowlesville (100), Medina (99), Ridgeway (95) (100); 1935, Lyndonville (587). ULSTER: 1934, Marlboro (149), Milton (196). WAYNE: 1934, Alton (99), East Williamson (99), Sodus (97), Williamson (100); 1935, Williamson (875).

NEW JERSEY:

BURLINGTON: 1933, Moorestown (23); 1934, Beverly (150), Masonville (149), Moorestown (142); 1935, Moorestown (508), Parry (577) (707). CAMDEN: 1934, Pennsauken (150). CUMBERLAND: 1934, Bridgeton (149) (146). GLOUCESTER: 1934, Glassboro (150), Richwood (112) (132).

PENNSYLVANIA:

ADAMS: 1933, Bendersville (55); 1934, Gettysburg (100); 1935, Biglerville (100), Flora Dale (400). FRANKLIN: 1934, Saint Thomas (100) (100), Scotland (100); 1935, Fayetteville (856), Rouzerville (275), Waynesboro (102).

MARYLAND:

WASHINGTON: 1934, Hancock (95), Smithsburg (100) (100); 1935, Hancock (570), Smithsburg (397).

VIRGINIA:

AMHERST: 1934, Elon (149), Monroe (148). AUGUSTA: 1935, Waynesboro (99). BOTETOURT: 1934, Cloverdale (149). ROANOKE: 1934, Bonsack (149), Roanoke (150). ROCKINGHAM: 1935, Timberville (195).

NORTH CAROLINA:

GASTON: 1934, Belmont (150). MONTGOMERY: 1934, Candor (149); 1935, Candor (408). MOORE: 1934, Eagle Springs (148) (150), West End (150) (150); 1935, West End (579) (598). RICHMOND: 1934, Marston (300). WAKE: 1934, Raleigh (148) (148).

OHIO:

OTTAWA: 1934, Gypsum (99). SUMMIT: 1934, West Richfield (95).

INDIANA:

KNOX: 1934, Decker (148), Oaktown (95).

MICHIGAN:

BERRIEN: 1934, Benton Harbor (98). VAN BUREN: 1934, South Haven (94).

Calliephialtes laspeyresiae

NEW JERSEY:

BURLINGTON: 1934, Moorestown (123); 1935, Parry (23).

Cremastus flavoorbitalis

(Included with this species are an undetermined number of *Cremastus* spp. from Japan and Chosen.)

CONNECTICUT:
HARTFORD: 1934, Southington (33).
NEW YORK:
NIAGARA: 1935, Olcott (51). ULSTER: 1935, Marlboro (89).
NEW JERSEY:
BURLINGTON: 1933, Moorestown (52); 1935, Parry (51).
PENNSYLVANIA:
ADAMS: 1933, Bendersville (31); 1935, Biglerville (83). FRANKLIN: 1932, Scotland (72); 1935, Waynesboro (6).
MARYLAND:
WASHINGTON: 1934, Smithsburg (40).
MICHIGAN:
BERRIEN: 1934, Eau Claire (12).

Elodia flavipalpis

(Included with this species are an undetermined number of *Elodia subfasciata* and *Phorocera pumilio*.)

CONNECTICUT:
HARTFORD: 1934, Southington (49).
NEW JERSEY:
BURLINGTON: 1933, Moorestown (111); 1935, Pennsauken (223).
PENNSYLVANIA:
ADAMS: 1933, Bendersville (32); 1935, Biglerville (58), Cashtown (17). FRANKLIN: 1934, Scotland (54); 1935, Blackgap (282), Waynesboro (2).
NORTH CAROLINA:
MOORE: 1935, West End (220). WAKE: 1934, Raleigh (105).
OHIO:
SUMMIT: 1934, West Richfield (2).

Eubadizon extensor

NEW JERSEY:
BURLINGTON: 1931, Moorestown (6); 1935, Parry (36) (73).

Gambrus stokesii

NEW JERSEY:
BURLINGTON: 1933, Parry (9).
VIRGINIA:
ALBEMARLE: 1933, Crozet (82).

Glypta rufiscutellaris

VIRGINIA:
ALBEMARLE: 1933, Crozet (210).
NORTH CAROLINA:
MOORE: 1935, West End (450). RICHMOND: 1935, Hamlet (230). WAKE: 1931, Raleigh (155).
SOUTH CAROLINA:
GREENVILLE: 1931, Greer (298).
GEORGIA:
HABERSHAM: 1931, Alto (377). JACKSON: 1931, Commerce (349).

Inareolata molestae

MASSACHUSETTS:
FRANKLIN: 1933, Shelburne (189), West Deerfield (170). HAMPDEN: 1933, East Longmeadow (160), Westfield (163) (122). MIDDLESEX: 1933, Marlboro (163). WORCESTER: 1933, Bolton (98), Grafton (121).
CONNECTICUT:
HARTFORD: 1933, Glastonbury (167), South Glastonbury (184). MIDDLESEX: 1933, Middlefield (191). NEW HAVEN: 1933, Guilford (218), Hamden (165). TOLLAND: 1933, Somers (195).

NEW YORK:

MONROE: 1933, Hilton (244) (236) (101); 1935, Webster (671). NIAGARA: 1935, Somerset (368). ONTARIO: 1933, Geneva (244). ORLEANS: 1933, Morton (124) (95); 1935, Albion (782), Murray (777), Waterport (602). ROCKLAND: 1932, Suffern (285); 1933, Spring Valley (150). SCHUYLER: 1933, Hector (239). SENECA: 1933, Lodi (185). ULSTER: 1933, Marlboro (79); 1935, Marlboro (556), Milton (392). WAYNE: 1934, East Williamson (166), North Rose (155), Ontario (172); 1935, Pultneyville (760), Sodus (380).

NEW JERSEY:

BURLINGTON: 1932, Masonville (200), Moorestown (500); 1933, Beverly (171) (144) (94) (108), Burlington (124), Cinnaminson (121), Evesboro (125) (150), Moorestown (125) (306) (94) (122) (95); 1935, Parry (149). CAMDEN: 1933, Haddonfield (95), Merchantville (259). GLOUCESTER: 1933, Richwood (125) (123). MERCER: 1933, Hopewell (121), Pennington (124).

PENNSYLVANIA:

ADAMS: 1933, Arendtsville (118) (115), Biglerville (125); 1935, Arendtsville (742), Biglerville (198), Cashtown (551) (627). FRANKLIN: 1933, Scotland (124); 1934, Saint Thomas (167) (167), Scotland (144); 1935, Waynesboro (49).

DELAWARE:

KENT: 1933, Camden (163). SUSSEX: 1933, Bridgeville (144) (152) (162), Georgetown (144).

MARYLAND:

DORCHESTER: 1933, Hurlock (118). WASHINGTON: 1933, Chewsville (100), Hancock (120) (115), Smithsburg (172); 1934, Chewsville (164), Hancock (164); 1935, Cavetown (753), Ringgold (757). WICOMICO: 1933, Salisbury (127). WORCESTER: 1933, Berlin (127).

VIRGINIA:

ALBEMARLE: 1933, near Afton (146), Crozet (444) (176) (147); 1935, Crozet (349). AUGUSTA: 1933, Staunton (339), Waynesboro (351) (149); 1935, Staunton (787), Waynesboro (399) (337). FREDERICK: 1935, Clear Brook (353). NELSON: 1935, Lovingston (1,175). ROCKINGHAM: 1933, Timberville (171) (95); 1935, Broadway (768), Timberville (774).

WEST VIRGINIA:

MORGAN: 1935, Cherry Run (386).

NORTH CAROLINA:

MONTGOMERY: 1933, Candor (134). MOORE: 1933, West End (134); 1935, West End (218).

SOUTH CAROLINA:

SPARTANBURG: 1933, Gramling (168), Spartanburg (95).

GEORGIA:

HABERSHAM: 1933, Alto (153) (147), Cornelia (174) (136) (202).

TENNESSEE:

ROANE: 1933, Dyllis (123), Harriman (235), Kingston (116) (296) (100).

OHIO:

CLERMONT: 1934, Mount Carmel (260). ERIE: 1934, Vermillion (168). LAKE: 1934, Painesville (175). LAWRENCE: 1934, Proctorville (266). LORAIN: 1934, Avon Lake (165), South Amherst (173). OTTAWA: 1934, Catawba Island (160), Danbury (175), Gypsum (171), Port Clinton (160). SUMMIT: 1934, West Richfield (118). WAYNE: 1934, Wooster (159).

INDIANA:

FLOYD: 1934, New Albany (245). HARRISON: 1934, New Amsterdam (247). JACKSON: 1934, Brownstown (199). KNOX: 1933, Decker (178), Oaktown (145), Vincennes (147) (190) (162); 1934, Decker (229) (110) (244), Oaktown (231). LAWRENCE: 1934, Mitchell (249). MARTIN: 1934, Shoals (241).

MICHIGAN:

BERRIEN: 1934, Berrien Springs (231), Eau Claire (243), Sodus (218), Derby (240). VAN BUREN: 1934, South Haven (229).

Macrocentrus ancylivorus

MASSACHUSETTS:

FRANKLIN: 1933, Shelburne (300), West Deerfield (500). HAMPDEN: 1930, Wilbraham (350); 1931, Hampden (400); 1932, Brimfield (175), East Longmeadow (450) (250) (344) (200), Hampden (500) (425) (200), Longmeadow (425), Westfield (500) (610) (175), Wilbraham (500) (250) (250); 1933, Agawam (296), Westfield (250) (263). HAMPSHIRE: 1932, Belchertown (171). MIDDLESEX: 1933, Waltham (215).

CONNECTICUT:

HARTFORD: 1929, Southington (999); 1930, Manchester (495), Windsor (482); 1932, Glastonbury (393) (350), South Glastonbury (350). NEW HAVEN: 1930, Hamden (103); 1932, Branford (350). NEW LONDON: 1930, Jewett City (104), Yantic (141). TOLLAND: 1930, Somers (277).

NEW YORK:

CHAUTAUQUA: 1930, Dunkirk (169), Fredonia (318), Westfield (495). MONROE: 1932, Greece (254), Ogden (244) (247), Parma (243), Sweden (245). NIAGARA: 1930, Ransomville (485) (298); 1931, Newfane (372), Olcott (400) (443). ORLEANS: 1931, Gaines (374), Lyndonville (374), Ridgeway (470); 1932, Albion (249), Holley (244), Kendall (242), Knowlesville (236), Lyndonville (239), Millers (353), Waterport (250). SCHUYLER: 1933, Burdett (195), Hector (189), Valois (224). WAYNE: 1933, East Williamson (168), Lyons (175) (132), Ontario (155) 160), Sodus (200) (198), Williamson (249).

PENNSYLVANIA:

ADAMS: 1932, Arendtsville (348); 1933, Arendtsville (223), Biglerville (173), Orrtanna (195). ALLEGHENY: 1930, Library (274). BEAVER: 1930, Beaver Falls (439). BERKS: 1931, Boyertown (375). ERIE: 1930, North East (198) North Girard (200); 1931, Mooreheadville (363). FRANKLIN: 1931, Quincy (373), Scotland (427) (178); 1933, Scotland (196) (193) (174); 1935, Blackgap (70). JUNIATA: 1932, McAlisterville (348) (343). LEBANON: 1932, Annville (349). SNYDER: 1931, Middleburg (374). WASHINGTON: 1931, Centerville (363). YORK: 1931, Manchester (372), Stewartstown (370).

MARYLAND:

FREDERICK: 1931, Frederick (362), Mount Airy (318). TALBOT: 1930, Easton (112). WASHINGTON: 1930, Hancock (121); 1931, Hancock (471) (470) (404) (373), Smithsburg (371); 1932, Hancock (236) (236) (220), Smithsburg (246) (250); 1933, Chewsville (174), Clear Spring (194), Smithsburg (199) (220). WORCESTER: 1930, Berlin (275).

VIRGINIA:

ALBEMARLE: 1931, Crozet (460); 1932, near Afton (255), Crozet (317) (250) 1934, Batesville (1,048), Charlottsville (519), Ivy (522). AUGUSTA: 1931, Staunton (910); 1932, Waynesboro (250) (247). FREDERICK: 1931, Winchester (472). LOUDOUN: 1932, Leesburg (251). RAPPAHANNOCK: 1932, Washington (275). ROANOKE: 1931, Bonsack (475). ROCKINGHAM: 1932, Timberville (256).

NORTH CAROLINA:

HOKE: 1931, near Aberdeen (363). LEE: 1930, Sanford (367). MONTGOMERY: 1931, Candor (335); 1935, Candor (205) (880). MOORE: 1930, West End (477); 1931, Samarcand (374), West End (399); 1935, West End (497) (760) (845). RICHMOND: 1931, Hamlet (444), near Jackson Springs (336), Marston (424). SCOTLAND: 1931, east of Hamlet (329). SURRY: 1931, Mount Airy (372). WAKE: 1930, Raleigh (446) (351); 1931, Raleigh (496) (328) (394); 1935, Raleigh (470) (730).

SOUTH CAROLINA:

ANDERSON: 1931, Pendleton (365). CHESTER: 1930, Lowrys (296). GREENVILLE: 1930, Greer (315) (362); 1931, Greenville (374), Greer (369); 1932, Greenville (250), Greer (492) (248) (247) (244), Taylors (491). KERSHAW: 1931, Lugoff (394). LAURENS: 1930, Laurens (424) (244); 1931, Cross Hill (371), Ora (372). PICKENS: 1931, Pickens (374). SPARTANBURG: 1930, Duncan (213), Gramling (315); 1931, Inman (400); 1932, Gramling (241), Inman (245) (243), Spartanburg (247). YORK: 1930, Fort Mill (307).

GEORGIA:

BANKS: 1932, south of Alto (239). BARTOW: 1934, Adairsville (250). CHATTOOGA: 1934, Menlo (247), Summerville (248). COWETA: 1932, Madras (370), Newnan (242). FAYETTE: 1932, Woolsey (245). HABERSHAM: 1930, Alto (65) (317), Cornelia (68); 1931, Alto (370), Baldwin (347), Mount Airy (371), Sanatorium (367); 1932, Baldwin (245), Hollywood (236); 1934, Alto (239). HENRY: 1931, Hampton (368), Luella (369). JACKSON: 1931, Commerce (348); 1934 Center (235), Commerce (242). JASPER: 1932, Monticello (336). MERIWETHER: 1931, Woodbury (307), 1932, Gay (236) (363). MORGAN: 1932, Madison (179). POLK: 1934, Esom Hill (249) (250). SPAULDING: 1931, Griffin (259). UPSON: 1931, Thomaston (350).

TENNESSEE:

ANDERSON: 1931, Clinton (355). BRADLEY: 1931, Cleveland (369). KNOX: 1931, Knoxville (372). ROANE: 1930, Harriman (359) (89); 1931, Clark's Gap (397), Harriman (329), Kingston (333) (432) (439); 1932, Harriman (241), Kingston (230) (238) (231) (384) (392).

KENTUCKY:

BULLITT: 1932, near Valley Station (350). DAVIESS: 1932, Owensboro (375). FAYETTE: 1932, Lexington (373). HENDERSON: 1929, Henderson (168) 1930, Henderson (622) (413); 1931, Henderson (375). HOPKINS: 1932, Madisonville (350) (350). JEFFERSON: 1930, Jeffersontown (399); 1932, Louisville (344). KENTON: 1930, Cresent Springs (208). MCCRACKEN: 1930, Paducah (165) (200). OLDHAM: 1930, near Prospect (468). UNION: 1930, Morganfield (328). WARREN: 1932, Bowling Green (344).

OHIO:

ASHLAND: 1932, Jeromesville (243). ASHTABULA: 1932, Ashtabula (250), Conneaut (248). BELMONT: 1931, Barnesville (359). BUTLER: 1932, Middletown (487). CLERMONT: 1930, Mount Carmel (195). COLUMBIANA: 1931, Washingtonville (389). CUYAHOGA: 1931, Strongsville (395). ERIE: 1930, Venice (408); 1931, Vermilion (375) (495). FAIRFIELD: 1931, Carroll (399); 1932, Lancaster (249). FRANKLIN: 1930, Columbus (306); 1932, Lockborne (249). HAMILTON: 1930, Blue Ash (405). KNOX: 1931, near New Castle (370). LAKE: 1930, Painesville (472); 1932, Madison (249). LAWRENCE: 1930, Proctorville (482); 1932, Proctorville (347) (341), South Point (345). LORAIN: 1930, Avon Lake (455), South Amherst (479); 1934, Avon Lake (309), Lorain (284), South Amherst (282). MEIGS: 1932, Middleport (241). MONTGOMERY: 1932, Brookville (245). OTTAWA: 1930, Danbury (797); 1931, Gypsum (426), Oakharbor (483); 1932, Oakharbor (340). ROSS: 1931, Chillicothe (499); 1932, Bourneville (250). SUMMIT: 1931, West Richfield (488). WAYNE: 1931, Orrville (399), Rittman (385); 1934, Orrville (270), Smithville (287), Wooster (282).

INDIANA:

BROWN: 1930, Mount Liberty (285). Daviess: 1931, Washington (395). DEARBORN: 1931, Aurora (332). FLOYD: 1930, New Albany (365). FRANKLIN: 1931, Brookville (428). GIBSON: 1930, near Poseyville (332). GREENE: 1931, Linton (366). HARRISON: 1931, New Amsterdam (128). JACKSON: 1931, Brownstown (373). JOHNSON: 1931, Edinburg (371). KNOX: 1929, Vincennes (415) (440); 1930, Decker (365), Vincennes (129); 1931, Oaktown (351). LAWRENCE: 1929, Mitchell (378). MARTIN: 1930, Shoals (371); 1934, Shoals (449). MORGAN: 1930, Mooresville (105). ORANGE: 1930, Paoli (326). OWEN: 1931, Spencer (367). POSEY: 1930, Mount Vernon (345). WARRICK: 1930, Newburgh (379). WASHINGTON: 1931, Salem (444).

MICHIGAN:

ALLEGAN: 1931, Fennville (400); 1934, Casco Township (432) (416). BERRIEN: 1932, Berrien Springs (258), Royalton (250), Eau Claire (250), Lakeside (250), Millburg (249), Sodus (249), Watervliet (250); 1934, Berrien Center (353), Berrien Springs (388), Eau Claire (437), Royalton (367), Sodus (391) (401). OAKLAND: 1932, Farmington (425), Novi (250) (425), Rochester (250) (425). VAN BUREN: 1931, South Haven (445); 1934, Geneva (422), South Haven (409).

ILLINOIS:

ALEXANDER: 1931, Thebes (490). CLAY: 1930, Flora (394); 1932, Flora (247). FRANKLIN: 1932, Benton (250). JACKSON: 1932 Carbondale (250), Makanda (250). JEFFERSON: 1930, near Centralia (363), Texico (320); 1932, Mount Vernon (421). JOHNSON: 1932, Tunnel Hill (250). MARION: 1930, Alma (186), Centralia (378), Salem (387); 1931, Centralia (375); 1932, Salem (396). MASSAC: 1932, Metropolis (252). PERRY: 1932, Tamaroa (421). PULASKI: 1931, Villa Ridge (444) (425); 1932, Villa Ridge (250). RICHLAND: 1930, Olney (362); 1932, Olney (247). SAINT CLAIR: 1932, Belleville (421). UNION: 1930, Jonesboro (367); 1931, Cobden (450); 1932, Anna (250). WASHINGTON: 1932, Irvington (247). WILLIAMSON: 1930, Carterville (192); 1932, Creal Springs (250).

MISSOURI:

BUTLER: 1932, Poplar Bluff (157). CAPE GIRARDEAU: 1931, Cape Girardeau (435), Jackson (432); 1932, Jackson (164); 1934, Cape Girardeau (901). DUNKLIN: 1934, Campbell (835). JEFFERSON: 1934, Kimmswick (432.) LAWRENCE: 1932, Marionville (169) (187). PEMISCOT: 1932, Caruthersville (187). SCOTT: 1931, Sikeston (372); 1932, Fornfelt (166); 1934, Illmo (425), Sikeston (417). SAINT LOUIS: 1934, Jefferson Barracks (435) (436).

ARKANSAS:

BENTON: 1931, Rogers (477); 1932, Lowell (324). LEE: 1934, Marianna (249) (246) (245). PHILLIPS: 1934, Barton (249). SAINT FRANCIS: 1934, Forrest City (245), Hughes (245) (239) (248). WASHINGTON: 1932, Fayetteville (367), Springdale (334).

Macrocentrus thoracicus

(Included with this species are an undetermined number of *Eubadizon extensor* from Chosen and Japan.)

CONNECTICUT:
NEW HAVEN: 1934, Northford (218).
NEW YORK:
MONROE: 1934, Greece (310), Hilton (179), Spencerport (184), Webster (156); 1935, Morton (521), Walker (492), NIAGARA: 1934, Olcott (162) (175), Wilson (170); 1935, Olcott (443) (528). ONTARIO: 1933, Geneva (98). ORANGE: 1933, Newburgh (250); 1935, Newburgh (523). ULSTER: 1933, Marlboro (231) (257); 1935, Milton (724) (494). WAYNE: 1934, Sodus (176), Williamson (152); 1935, Williamson (130).
NEW JERSEY:
BURLINGTON: 1933, Moorestown (685) (225) (236); 1935, Cinnaminson (283). CAMDEN: 1933, west of Marlton (256); 1934, Pennsauken (288).
PENNSYLVANIA:
ADAMS: 1933, Brysonia (201); 1934, Gettysburg (150). FRANKLIN: 1935, Waynesboro (116).
DELAWARE:
SUSSEX: 1933, Bridgeville (248).
MARYLAND:
DORCHESTER: 1933, Hurlock (417). WASHINGTON: 1933, Hancock (225), Smithsburg (218); 1935, Hancock (810). WICOMICO: 1933, Salisbury (574).
VIRGINIA:
ROCKINGHAM: 1933, Timberville (227).
NORTH CAROLINA:
GASTON: 1934, Belmont (194). MONTGOMERY: 1933, Candor (207); 1935, Candor (82). MOORE: 1933, West End (218); 1934, Eagle Springs (294), West End (264).
SOUTH CAROLINA:
GREENVILLE: 1933, Greenville (237) (266) (237). SPARTANBURG: 1933, Gramling (250), Inman (235).
INDIANA:
KNOX: 1934, Decker (182) (202).
MICHIGAN:
BERRIEN: 1934, Benton Harbor (245).

Orgilus longiceps

MASSACHUSETTS:
HAMPDEN: 1933, Westfield (77).
CONNECTICUT:
HARTFORD: 1934, Southington (59). NEW HAVEN: 1933, Guilford (84).
NEW YORK:
NIAGARA: 1934, Ridgewood (148); 1935, Olcott (173). ORLEANS: 1934, Albion (154). WAYNE: 1935, Williamson (61).
NEW JERSEY:
BURLINGTON: 1935, Parry (44). CAMDEN: 1935, Pennsauken (175).
PENNSYLVANIA:
ADAMS: 1935, Biglerville (430). FRANKLIN: 1934, Scotland (168); 1935, Rouzerville (6).
VIRGINIA:
ROCKINGHAM: 1933, Timberville (149).
NORTH CAROLINA:
MOORE: 1934, West End (111); 1935, West End (226).
SOUTH CAROLINA:
SPARTANBURG: 1933, Gramling (112).

Perisierola angulata

MASSACHUSETTS:
HAMPDEN: 1932, East Longmeadow (490); 1933, East Longmeadow (247), Westfield (237).
NEW YORK:
NIAGARA: 1932, Olcott (437). ROCKLAND: 1932, Monsey (469).
NEW JERSEY:
ATLANTIC: 1932, Hammonton (492); 1933, Hammonton (222) (133) (226). BURLINGTON: 1932, Beverly (495), Evesboro (355), Moorestown (446) (487),

Parry, (467); 1933, Beverly (242), Fellowship (336), Delanco (244), Medford (242) (239), Moorestown (249) (225) (272) (247) (249), Parry (312). CAMDEN: 1933, Elm (241) (250). GLOUCESTER: 1932, Glassboro (492); 1933, Richwood (248).

PENNSYLVANIA:

ADAMS: 1933, Arendtsville (243). FRANKLIN: 1932, Scotland (489) (492). LANCASTER: 1932, Neffsville (498). YORK: 1933, Manchester (243).

DELAWARE:

SUSSEX: 1932, Bridgeville (497).

MARYLAND:

WASHINGTON: 1932, Hancock (495), Smithsburg (495); 1933, Hancock (243), Ringgold (742). WORCESTER: 1932, Berlin (498).

VIRGINIA:

ALBEMARLE: 1932, Crozet (499); 1933, near Afton (239), Crozet (235) (243) (242) (242) (240) (240) (242) (230). AUGUSTA: 1933, Staunton (245), Waynesboro (247) (241) (236). ROCKINGHAM: 1932, Timberville (496).

NORTH CAROLINA:

MONTGOMERY: 1933, Candor (239). MOORE: 1933, West End (242) (241) (250). WAKE: 1932, Raleigh (457).

SOUTH CAROLINA:

ANDERSON: 1933, Pendleton (247). GREENVILLE: 1933, Greer (245) (249), Taylors (243). SPARTANBURG: 1933, Inman, (242).

TENNESSEE:

ROANE: 1932, Harriman (494), Kingston (495); 1933, Harriman (244) (246) (244).

KENTUCKY:

HENDERSON: 1932, Henderson (490).

OHIO:

OTTAWA: 1932, Port Clinton (487)

INDIANA:

KNOX: 1932, Vincennes (448) (481).

ILLINOIS:

JACKSON: 1932, Carbondale (483). MARION: 1932, Centralia (490).

Perisierola sp. (from Japan)

MARYLAND:

WICOMICO: 1935, Salisbury (332) (400) (400).

Phaeogenes haeussleri

NEW JERSEY:

BURLINGTON: 1934, Beverly (70), Parry (130).

MARYLAND:

WASHINGTON: 1935, Ringgold (1,624) (140). WICOMICO: 1935, Salisbury (208).

NORTH CAROLINA:

MOORE: 1935, West End (2,000).

Phanerotoma grapholithae

MASSACHUSETTS:

FRANKLIN: 1933, West Deerfield (96). HAMPDEN: 1933, East Longmeadow (75). MIDDLESEX: 1933, Groton (91). WORCESTER: 1933, Auburn (96), Grafton (91), Harvard (97).

CONNECTICUT:

HARTFORD: 1933, Glastonberry (99), South Glastonberry (100). MIDDLESEX: 1933, Middlefield (100). NEW HAVEN: 1933, Hamden (100); 1934, Hamden (223).

NEW YORK:

DUTCHESS: 1934, Annandale-on-Hudson (397), Red Hook (395), Rock City (391). MONROE: 1933, Hamlin (96), Walker (94); 1934, Greece (297) (300), Hilton (291), Rochester (296) (296) (291), Spencerport (293), Webster (286) (291). NIAGARA: 1934, Lockport (136), Royalton Center (143). ORANGE: 1933, Campbell Hall (92), Middle Hope (92); 1934, Newburgh (395) (397). ORLEANS: 1933, Morton (116). ROCKLAND: 1933, Monsey (98), Pomona (95). ULSTER: 1934, Marlboro (393). WAYNE: 1934, Wallington (143).

NEW JERSEY:

ATLANTIC: 1933, Hammonton (100) (100). BURLINGTON: 1933, Beverly (100) (100) (100) (96), Bridgeboro (93), Delanco (193), Fellowship (100), (100),

Hainesport (99), Moorestown (70) (100) (100) (100) (100), Parry (96 ((95), Riverton (95); 1935, Parry (97). CAMDEN: 1933, Merchantville (99), Pennsauken (95). GLOUCESTER: 1933, Glassboro (100); 1934, Glassboro (575), Richwood (623). MERCER: 1933, Hopewell (98), Lawrenceville (98).

PENNSYLVANIA:

ADAMS: 1933, Arendtsville (198) (195) (100), Brysonia (196), Gardners (180); 1935, Biglerville (52). FRANKLIN: 1933, Scotland (100) (99); 1935, Waynesboro (42). YORK: 1933, Manchester (98).

DELAWARE:

KENT: 1933, Camden (243). SUSSEX: 1933, Bridgeville (192) (188) (191), Greenwood (190) (200).

MARYLAND:

WASHINGTON: 1933, Chewsville (99) (198), Hancock (96), Smithsburg (98) (198) (198); 1934, Hancock (142). WICOMICO: 1933, Salisbuy (188) (191). WORCESTER: 1933, Berlin (186).

VIRGINIA:

ALBEMARLE: 1933, near Afton (95), Crozet (99) (174) (100) (98) (98), Greenwood (99) (99). AUGUSTA: 1933, Staunton (98), Waynesboro (96) (94) (100) (100). BOTETOURT: 1934, Cloverdale (225). ROANOKE: 1934, Bonsack (223). ROCKINGHAM: 1933, Broadway (98), Timberville (97) (96); 1935, Timberville (603).

NORTH CAROLINA:

GASTON: 1934, Belmont (300). MONTGOMERY: 1934, Candor (233). MOORE: 1933, West End (88) (84). RICHMOND: 1934, Marston (300). WAKE: 1934, Raleigh (298) (151).

SOUTH CAROLINA:

GREENVILLE: 1933, Greer (96) (77). PICKENS: 1933, Pickens (38) (43). SPARTANBURG: 1933, Inman (80), Gramling (90) (80).

GEORGIA:

HABERSHAM: 1933, Alto (98), Cornelia (92) (96).

TENNESSEE:

ROANE: 1933, Dyliss (85), Harriman (99) (45), Kingston (99) (20) (21) (44).

INDIANA:

KNOX: 1933, Vincennes (97) (84).

Pristomerus ocellatus

GEORGIA:

HABERSHAM: 1931, Baldwin (438).

TENNESSEE:

ROANE: 1931, Harriman (472), Kingston (309).

INDIANA:

KNOX: 1931, Decker (491).

Pristomerus vulnerator

(All liberations previous to 1932 were of European origin, all subsequent to 1932 were from Japan and Chosen.)

CONNECTICUT:

HARTFORD: 1934, Southington (50).

NEW YORK:

NIAGARA: 1935, Olcott (32). ROCKLAND: 1931, Spring Valley (440). ULSTER: 1935, Marlboro (59). WAYNE: 1935, Williamson (67).

NEW JERSEY:

BURLINGTON: 1930, Moorestown (193); 1931, Moorestown (1,015) (84); 1933, Moorestown (40); 1935, Parry (249).

PENNSYLVANIA:

ADAMS: 1933, Bendersville (4); 1935, Biglerville (62). FRANKLIN: 1935, Waynesboro (245).

MARYLAND:

WASHINGTON: 1934, Smithsburg (71).

TENNESSEE:

ROANE: 1931, Harriman (218).

OHIO:

SUMMIT: 1934, West Richfield (47).

MICHIGAN:

BERRIEN: 1934, Eau Claire (30).

Trichogramma euproctidis

MASSACHUSETTS:
HAMPDEN: 1932, Wilbraham (55,000).
NEW YORK:
NIAGARA: 1932, Ransomville (22,500). ORANGE: 1932, Middle Hope (50,000).
NEW JERSEY:
BURLINGTON: 1932, Moorestown (81,000).
MARYLAND:
WASHINGTON: 1932, Hancock (45,000). WORCESTER: 1932, Berlin (49,000).
NORTH CAROLINA:
MOORE: 1932, West End (38,400).
GEORGIA:
HABERSHAM: 1932, Alto (62,700).
TENNESSEE:
ROANE: 1932, Harriman (32,400), Kingston (25,000).
OHIO:
LAKE: 1932, Painesville (34,000). LORAIN: 1932, Lorain (44,100).
ILLINOIS:
JOHNSON: 1932, Ozark (31,200).

Trichomma enecator

NEW JERSEY:
BURLINGTON: 1931, Moorestown (122) (83).

Zenillia roseanae

(Included here are an undetermined number of *Actia tibialis* and *Arrhinomyia tragica*.)

NEW JERSEY:
BURLINGTON: 1930, Moorestown (5); 1931, Moorestown (8) (79).

LIST OF RELEASES BY STATES AND COUNTIES

The list which follows includes all counties receiving liberations, and the species of parasites liberated in each are given. Additional information as to the liberation of any particular species in any county can be obtained by referring to the preceding list, in which the data are entered under the heading of the parasite name.

MASSACHUSETTS:
FRANKLIN: *Inareolata molestae, Macrocentrus ancylivorus, Phanerotoma grapholithae.*
HAMPDEN: *Inareolata molestae, Macrocentrus ancylivorus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae, Trichogramma euproctidis.*
MIDDLESEX: *Inareolata molestae, Macrocentrus ancylivorus, Phanerotoma grapholithae.*
WORCESTER: *Inareolata molestae, Phanerotoma grapholithae.*
HAMPSHIRE: *Macrocentrus ancylivorus.*
CONNECTICUT:
FAIRFIELD: *Bassus diversus.*
HARTFORD: *Apanteles* spp. (from Japan), *Bassus diversus, Cremastus flavoorbitalis* and others, *Elodia flavipalpis* and others, *Inareolata molestae, Macrocentrus ancylivorus, Orgilus longiceps, Phanerotoma grapholithae, Pristomerus vulnerator.*
MIDDLESEX: *Bassus diversus, Inareolata molestae, Phanerotoma grapholithae.*
NEW HAVEN: *Ascogaster quadridentatus, Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Phanerotoma grapholithae.*
NEW LONDON: *Macrocentrus ancylivorus.*
TOLLAND: *Inareolata molestae, Macrocentrus ancylivorus.*
NEW YORK:
CHAUTAUQUA: *Macrocentrus ancylivorus.*
DUTCHESS: *Bassus diversus, Phanerotoma grapholithae.*
MONROE: *Apanteles* spp. (from Japan), *Bassus diversus, Inareolata molestae,*

Macrocentrus ancylivorus, M. thoracicus, Phanerotoma grapholithae.

NIAGARA: *Apanteles* spp. (from Japan), *Ascogaster quadridentatus, Bassus diversus, Cremastus flavoorbitalis* and others, *Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae, Pristomerus vulnerator, Trichogramma euproctidis.*

ONTARIO: *Inareolata molestae, Macrocentrus thoracicus.*

ORANGE: *Ascogaster quadridentatus, Bassus diversus, Macrocentrus thoracicus, Phanerotoma grapholithae, Trichogramma euproctidis.*

ORLEANS: *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, Orgilus longiceps, Phanerotoma grapholithae.*

ROCKLAND: *Ascogaster quadridentatus, Inareolata molestae, Perisierola angulata, Phanerotoma grapholithae, Pristomerus vulnerator.*

SCHUYLER: *Inareolata molestae, Macrocentrus ancylivorus.*

SENECA: *Inareolata molestae.*

ULSTER: *Bassus diversus, Cremastus flavoorbitalis* and others, *Inareolata molestae, Macrocentrus thoracicus, Phanerotoma grapholithae, Pristomerus vulnerator.*

WAYNE: *Apanteles* spp. (from Japan), *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Phanerotoma grapholithae, Pristomerus vulnerator.*

NEW JERSEY:

ATLANTIC: *Ascogaster quadridentatus, Perisierola angulata, Phanerotoma grapholithae.*

BURLINGTON: *Apantales anarsiae, Apanteles* spp. (from Japan), *Ascogaster quadridentatus, Bassus diversus, Calliephialtes laspeyresiae, Cremastus flavoorbitalis* and others, *Elodia flavipalpis* and others, *Eubadizon extensor, Gambrus stokesii, Inareolata molestae, Macrocentrus thoracicus, Orgilus longiceps, Perisierola angulata, Phaeogenes haeussleri, Phanerotoma grapholithae, Pristomerus vulnerator, Trichogramma euproctidis, Trichomma enecator, Zenillia roseanae* and others.

CAMDEN: *Ascogaster quadridentatus, Bassus diversus, Inareolata molestae, Macrocentrus thoracicus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae.*

CUMBERLAND: *Bassus diversus.*

GLOUCESTER: *Ascogaster quadridentatus, Bassus diversus, Inareolata molestae, Perisierola angulata, Phanerotoma grapholithae.*

MERCER: *Inareolata molestae, Phanerotoma grapholithae.*

PENNSYLVANIA:

ADAMS: *Apanteles* spp. (from Japan), *Bassus diversus, Cremastus flavoorbitalis* and others, *Elodia flavipalpis* and others, *Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae, Pristomerus vulnerator.*

ALLEGHENY: *Macrocentrus ancylivorus.*

BEAVER: *Macrocentrus ancylivorus.*

BERKS: *Macrocentrus ancylivorus.*

ERIE: *Macrocentrus ancylivorus.*

FRANKLIN: *Apanteles* spp. (from Japan), *Bassus diversus, Cremastus flavoorbitalis* and others, *Elodia flavipalpis* and others, *Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae, Pristomerus vulnerator.*

JUNIATA: *Macrocentrus ancylivorus.*

LANCASTER: *Perisierola angulata.*

LEBANON: *Macrocentrus ancylivorus.*

SNYDER: *Macrocentrus ancylivorus.*

WASHINGTON: *Macrocentrus ancylivorus.*

YORK: *Macrocentrus ancylivorus, Perisierola angulata, Phanerotoma grapholithae.*

DELAWARE:

KENT: *Ascogaster quadridentatus, Inareolata molestae, Phanerotoma grapholithae.*

SUSSEX: *Ascogaster quadridentatus, Inareolata molestae, Macrocentrus thoracicus, Perisierola angulata, Phanerotoma grapholithae.*

MARYLAND:

DORCHESTER: *Inareolata molestae, Macrocentrus thoracicus.*

FREDERICK: *Macrocentrus ancylivorus.*

TALBOT: *Macrocentrus ancylivorus.*

WASHINGTON: *Apanteles* spp. (from Japan), *Bassus diversus, Cremastus flavoorbitalis* and others, *Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus,*

Perisierola angulata, Phaeogenes haeussleri, Phanerotoma grapholithae, Pristomerus vulnerator, Trichogramma euproctidis.

WICOMICO: *Inareolata molestae, Macrocentrus thoracicus, Perisierola* n. sp. (from Japan), *Phaeogenes haeussleri, Phanerotoma grapholithae.*

WORCESTER: *Inareolata molestae, Macrocentrus ancylivorus, Perisierola angulata, Phanerotoma grapholithae, Trichogramma euproctidis.*

VIRGINIA:

ALBEMARLE: *Gambrus stokesii, Glypta rufiscutellaris, Inareolata molestae, Macrocentrus ancylivorus, Persierola angulata, Phanerotoma grapholithae.*

AMHERST: *Bassus diversus.*

AUGUSTA: *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, Perisierola angulata, Phanerotoma grapholithae.*

BOTETOURT: *Bassus diversus, Phanerotoma grapholithae.*

FREDERICK: *Inareolata molestae, Macrocentrus ancylivorus.*

LOUDOUN: *Macrocentrus ancylivorus.*

NELSON: *Inareolata molestae.*

RAPPAHANNOCK: *Macrocentrus ancylivorus.*

ROANOKE: *Bassus diversus, Macrocentrus ancylivorus, Phanerotoma grapholithae.*

ROCKINGHAM: *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae.*

WEST VIRGINIA:

MORGAN: *Inareolata molestae.*

NORTH CAROLINA:

GASTON: *Bassus diversus, Macrocentrus thoracicus, Phanerotoma grapholithae.*

HOKE: *Macrocentrus ancylivorus.*

LEE: *Macrocentrus ancylivorus.*

MONTGOMERY: *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Perisierola angulata, Phanerotoma grapholithae.*

MOORE: *Bassus diversus, Elodia flavipalpis* and others, *Glypta rufiscutellaris, Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Perisierola angulata, Phaeogenes haeussleri, Phanerotoma grapholithae, Trichogramma euproctidis.*

RICHMOND: *Bassus diversus, Glypta rufiscutellaris, Macrocentrus ancylivorus, Phanerotoma grapholithae.*

SCOTLAND: *Macrocentrus ancylivorus.*

SURRY: *Macrocentrus ancylivorus.*

WAKE: *Bassus diversus, Elodia flavipalpis* and others, *Glypta rufiscutellaris, Macrocentrus ancylivorus, Perisierola angulata, Phanerotoma grapholithae.*

SOUTH CAROLINA:

ANDERSON: *Macrocentrus ancylivorus, Perisierola angulata.*

CHESTER: *Macrocentrus ancylivorus.*

GREENVILLE: *Glypta rufiscutellaris, Macrocentrus ancylivorus, M. thoracicus, Perisierola angulata, Phanerotoma grapholithae.*

KERSHAW: *Macrocentrus ancylivorus.*

LAURENS: *Macrocentrus ancylivorus.*

PICKENS: *Macrocentrus ancylivorus, Phanerotoma grapholithae.*

SPARTANBURG: *Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Orgilus longiceps, Perisierola angulata, Phanerotoma grapholithae.*

YORK: *Macrocentrus ancylivorus.*

GEORGIA:

BANKS: *Macrocentrus ancylivorus.*

BARTOW: *Macrocentrus ancylivorus.*

CHATTOOGA: *Macrocentrus ancylivorus.*

COWETA: *Macrocentrua ancylivorus.*

FAYETTE: *Macrocentrus ancylivorus.*

HABERSHAM: *Glypta rufiscutellaris, Inareolata molestae, Macrocentrus ancylivorus, Phanerotoma grapholithae, Pristomerus ocellatus, Trichogramma euproctidis.*

HENRY: *Macrocentrus ancylivorus.*

JACKSON: *Glypta rufiscutellaris, Macrocentrus ancylivorus.*

JASPER: *Macrocentrus ancylivorus.*

MERIWETHER: *Macrocentrus ancylivorus.*

MORGAN: *Macrocentrus ancylivorus.*

POLK: *Macrocentrus ancylivorus.*

SPAULDING: *Macrocentrus ancylivorus.*

UPSON: *Macrocentrus ancylivorus.*

TENNESSEE:
ANDERSON: *Macrocentrus ancylivorus.*
BRADLEY: *Macrocentrus ancylivorus.*
KNOX: *Macrocentrus ancylivorus.*
ROANE: *Ascogaster quadridentatus, Inareolata molestae, Macrocentrus ancylivorus, Perisierola angulata, Phanerotoma grapholithae, Pristomerus ocellatus, P. vulnerator, Trichogramma euproctidis.*
KENTUCKY:
BULLITT: *Macrocentrus ancylivorus.*
DAVIESS: *Macrocentrus ancylivorus.*
FAYETTE: *Macrocentrus ancylivorus.*
HENDERSON: *Macrocentrus ancylivorus, Perisierola angulata.*
HOPKINS: *Macrocentrus ancylivorus.*
JEFFERSON: *Macrocentrus ancylivorus.*
KENTON: *Macrocentrus ancylivorus.*
MCCRACKEN: *Macrocentrus ancylivorus.*
OLDHAM: *Macrocentrus ancylivorus.*
UNION: *Macrocentrus ancylivorus.*
WARREN: *Macrocentrus ancylivorus.*
OHIO:
ASHLAND: *Macrocentrus ancylivorus.*
ASHTABULA: *Macrocentrus ancylivorus.*
BELMONT: *Macrocentrus ancylivorus.*
BUTLER: *Macrocentrus ancylivorus.*
CLERMONT: *Inareolata molestae, Macrocentrus ancylivorus.*
COLUMBIANA: *Macrocentrus ancylivorus.*
CUYAHOGA: *Macrocentrus ancylivorus.*
ERIE: *Inareolata molestae, Macrocentrus ancylivorus.*
FAIRFIELD: *Macrocentrus ancylivorus.*
FRANKLIN: *Macrocentrus ancylivorus.*
HAMILTON: *Macrocentrus ancylivorus.*
KNOX: *Macrocentrus ancylivorus.*
LAKE: *Inareolata molestae, Macrocentrus ancylivorus, Trichogramma euproctidis.*
LAWRENCE: *Inareolata molestae, Macrocentrus ancylivorus.*
LORAIN: *Inareolata molestae, Macrocentrus ancylivorus, Trichogramma euproctidis.*
MEIGS: *Macrocentrus ancylivorus.*
MONTGOMERY: *Macrocentrus ancylivorus.*
OTTAWA: *Ascogaster quadridentatus, Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, Perisierola angulata.*
ROSS: *Macrocentrus ancylivorus.*
SUMMIT: *Bassus conspicuus, B. diversus, Elodia flavipalpis* and others, *Inareolata molestae, Macrocentrus ancylivorus, Pristomerus vulnerator.*
WAYNE: *Inareolata molestae, Macrocentrus ancylivorus.*
INDIANA:
BROWN: *Macrocentrus ancylivorus.*
DAVIESS: *Macrocentrus ancylivorus.*
DEARBORN: *Macrocentrus ancylivorus.*
FLOYD: *Inareolata molestae, Macrocentrus ancylivorus.*
FRANKLIN: *Macrocentrus ancylivorus.*
GIBSON: *Macrocentrus ancylivorus.*
GREENE: *Macrocentrus ancylivorus.*
HARRISON: *Inareolata molestae, Macrocentrus ancylivorus.*
JACKSON: *Inareolata molestae, Macrocentrus ancylivorus.*
JOHNSON: *Macrocentrus ancylivorus.*
KNOX: *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Perisierola angulata, Phanerotoma grapholithae, Pristomerus ocellatus.*
LAWRENCE: *Inareolata molestae, Macrocentrus ancylivorus.*
MARTIN: *Inareolata molestae, Macrocentrus ancylivorus.*
MORGAN: *Macrocentrus ancylivorus.*
ORANGE: *Macrocentrus ancylivorus.*
OWEN: *Macrocentrus ancylivorus.*
POSEY: *Macrocentrus ancylivorus.*
WARRICK: *Macrocentrus ancylivorus.*
WASHINGTON: *Macrocentrus ancylivorus.*

MICHIGAN:
ALLEGAN: *Macrocentrus ancylivorus.*
BERRIEN: *Apanteles* spp. (from Japan), *Bassus conspicuus, B. diversus, Cremastus flavoorbitalis* and others, *Inareolata molestae, Macrocentrus ancylivorus, M. thoracicus, Pristomerus vulnerator.*
OAKLAND: *Macrocentrus ancylivorus.*
VAN BUREN: *Bassus diversus, Inareolata molestae, Macrocentrus ancylivorus.*
ILLINOIS:
ALEXANDER: *Macrocentrus ancylivorus.*
CLAY: *Macrocentrus ancylivorus.*
FRANKLIN: *Macrocentrus ancylivorus.*
JACKSON: *Macrocentrus ancylivorus, Perisierola angulata.*
JEFFERSON: *Macrocentrus ancylivorus.*
JOHNSON: *Macrocentrus ancylivorus, Trichogramma euproctidis.*
MARION: *Macrocentrus ancylivorus, Perisierola angulata.*
MASSAC: *Macrocentrus ancylivorus.*
PERRY: *Macrocentrus ancylivorus.*
PULASKI: *Macrocentrus ancylivorus.*
RICHLAND: *Macrocentrus ancylivorus.*
SAINT CLAIR: *Macrocentrus ancylivorus.*
UNION: *Macrocentrus ancylivorus.*
WASHINGTON: *Macrocentrus ancylivorus.*
WILLIAMSON: *Macrocentrus ancylivorus.*
MISSOURI:
BUTLER: *Macrocentrus ancylivorus.*
CAPE GIRARDEAU: *Macrocentrus ancylivorus.*
DUNKLIN: *Macrocentrus ancylivorus.*
JEFFERSON: *Macrocentrus ancylivorus.*
LAWRENCE: *Macrocentrus ancylivorus.*
PEMISCOT: *Macrocentrus ancylivorus.*
SCOTT: *Macrocentrus ancylivorus.*
SAINT LOUIS: *Macrocentrus ancylivorus.*
ARKANSAS:
BENTON: *Macrocentrus ancylivorus.*
LEE: *Macrocentrus ancylivorus.*
PHILLIPS: *Macrocentrus ancylivorus.*
SAINT FRANCIS: *Macrocentrus ancylivorus.*
WASHINGTON: *Macrocentrus ancylivorus.*

DISCUSSION OF SPECIES OF PARASITES HANDLED

Among the parasites of the twig-larval stages of the fruit moth there is a fair degree of uniformity of habit. Usually the female oviposits within the body of the host larva during a considerable growth range from hatching to the final instar. Oviposition is generally effected by making use of the aperture and tunnel made by the developing larva. The host usually develops to the prepupal stage within the completed cocoon before dying. The adult parasite is usually diurnal, though several species are crepuscular or nocturnal. Only one parasite larva issues from each host, and it spins its cocoon within the cocoon of the host. Probably most species have alternate hosts that serve as important reservoirs of population at times when the fruit moth larvae are not accessible in large numbers, though by 1935 this had not been confirmed for the foreign species. Some species, under laboratory conditions, are nicely synchronized with the seasonal and generation cycles of the fruit moth and display little or no tendency toward a pace of development that would throw them out of time with the developmental cycle of the fruit moth at any season of the year.

There is no large group of cocoon or egg parasites with the same general habits.

Aenoplex molestae (Uchida)

The parasite *Aenoplex molestae* is fairly abundant in fruit moth cocoons in Japan. In 1933, 398 parasite cocoons and 3 adults were received in 2 consignments from Yokohama. A preliminary test was made under quarantine-room conditions, to determine the inclination of this species to hyperparasitism, and it was found that cocoons of *Glypta* and *Calliephialtes* were attacked as freely as the cocoons of the fruit moth. The parasite also made attempts to oviposit in the cocoons of *Macrocentrus* but apparently could not penetrate them because of their close texture. The host prepupa is paralyzed by stinging, and an egg is deposited on the integument. Both sexes emerged from parasite cocoons that had been attacked. This species evidently belongs to the large group of cocoon parasites that attack freely both the lepidopterous host and its primary hymenopterous parasites. As soon as this point had been determined, all living material held at the receiving station was destroyed, and work with the species was terminated.

Angitia monospilia Thomson

A single specimen of *Angitia monospilia* emerged in 1931 as a hyperparasite from cocoons of *Pristomerus vulnerator* imported from southern Europe.

Antrocephalus stokesi (Crawford)

R. W. Burrell found a species (*Antrocephalus stokesi*) to be a fairly promising primary parasite of oriental fruit moth cocoons in the vicinity of Sydney, Australia. In 1932, 2,400 pupae were received from Australia, but it was estimated that only about 150 were alive when received. Adults were obtained under quarantine-room conditions, and the stock was readily increased by breeding on oriental fruit moth cocoons. It was then tested for tendency to hyperparasitism and was found to attack the cocoons of *Macrocentrus ancylivorus*. When cocoons of this latter parasite were exposed in combination with the cocoons of the oriental fruit moth, both were attacked by *Antrocephalus* with no evidence of preference. Adults of *Antrocephalus* in considerable numbers were obtained from the *Macrocentrus* cocoons attacked. The evidence obtained indicated that this species was a hyperparasite, as well as a primary parasite of fruit moth cocoons, and therefore not desirable for introduction, so work with this species was terminated, and all living stock was destroyed.

Apanteles anarsiae Faure and Alabouvette

Apanteles anarsiae was found to occur as a parasite of twig-infesting larvae in southeastern France. It was more abundant early in spring as a parasite of *Anarsia lineatella*, but was reared occasionally from the oriental fruit moth. It was imported in 1931 as host-free cocoons and also as developing larvae within host cocoons. From the 152 cocoons received alive, only 11.8 percent emerged. A total of 23 adults were obtained, of which only 8 were released. These were liberated at Moorestown. From the small numbers and lack of vigor of adults released, it is unlikely that the species could have become

established. If it should become established it is likely that it would not be so abundant on the fruit moth as on *A. lineatella*. No recoveries have been obtained. There has been no attempt to breed it in confinement.

Apanteles molestae Muesebeck, and others

Apanteles molestae, *A. taragamae* Viereck, and other, undetermined, species of *Apanteles* occur as parasites of twig-infesting larvae of the fruit moth in both Japan and Chosen. They have been imported from 1933 to 1935, inclusive. Active adults cannot be readily separated, so all species are handled together. Survey records made in Japan indicate that *A. taragamae* is about twice as abundant as *A. molestae*, whereas the other species are only occasionally encountered. During the 3 years that importations were received, 1,078 adults were reared, nearly all of which were obtained from consignments of host-free cocoons. The lack of vitality in adults reared at Moorestown has been much more pronounced than that of the average of the imported species handled. Only 552 have been released, and the difference, which is 40 percent of production, represents the high mortality during the period they were being held for shipment and the mortality in transit. The latter was 27.9 percent in 1935. There have been 10 releases ranging in size from 4 to 139 parasites. Seven days after the release of 29 adults at Williamson, N. Y., in 1935, a small collection of infested twigs was made from which two adults of *A. molestae* were reared. This is the first and only time this species was recovered. No attempt has been made to breed it in confinement.

Ascogaster quadridentatus Wesmael

Ascogaster quadridentatus is common in North America as a parasite of the codling moth and less commonly of the oriental fruit moth. It is a parasite of the fruit moth in southeastern France, and in Liguria, Italy. Since the fruit moth in some peach-growing districts in Europe showed heavier parasitization by this species than in any section of the United States, it was considered possible that the European form might be a strain more effective on the fruit moth than that occurring in North America. Because of this possibility it was imported from Europe during 1930 and 1931.

In its habits this parasite differs from most parasites of the fruit moth larvae in that it attacks the egg and emerges from the cocoon. This fact undoubtedly accounts for its comparative abundance late in the season in fruit-infesting larvae, at a time when parasites of the twig-infesting larvae are uncommon or absent. No tendency to premature cocooning in overwintering stock has been noted. The adult is diurnal.

From the first consignment of 255 host-free cocoons obtained in 1930, 74 adults were reared. These were sufficient for beginning mass breeding, and though several hundred adult parasites were subsequently reared from later importations, the many thousands obtained for release were secured principally by propagation from the few adults emerging from the first consignment. During 1931 and 1932 more than 56,000 adults were produced, and an additional 8,000 cocoons of the fruit moth containing this parasite were carried through the winter of 1932–33. The difference between the numbers received

and produced and the numbers liberated is 22.3 percent of production and represents stock used in breeding and the relatively low mortality in transit. In 1933 it was found not feasible to continue breeding, so the stock was transferred to the Connecticut Agricultural Experiment Station, where breeding and liberations were continued.

During 1931 extensive liberations were made in Burlington, Camden, and adjoining counties in New Jersey. In 1932 several more liberations were made in 5 additional States from Connecticut to Tennessee. Ninety-one lots totaling 44,757 parasite adults have been released. The average of 492 adults in each release is higher than for any other species released except *Trichogramma euproctidis* and *Phaeogenes haeussleri*.

Owing to the taxonomic identity of the American and the European forms of this parasite it has not been possible to determine the degree of persistence of the European admixture. Any significant change in the rate of parasitization of the fruit moth in sections colonized with this strain would furnish indirect evidence of this, but no such change has been noted.

Bassus conspicuus (Wesmael)

Bassus conspicuus, an occasional parasite of the twig-infesting larvae of the fruit moth in Chosen and the island of Hondo, Japan, was obtained during 1934 and 1935 in small numbers from importations of host-free parasite cocoons. Forty adults were obtained, of which 34 were reared in 1934. During this year 2 small liberations totaling 29 adults were made. Establishment from such small releases is possible but not likely. No recoveries have been made and propagation has not been attempted.

Bassus diversus Muesebeck

Beginning in 1933, *Bassus diversus*, a parasite of twig-infesting larvae of the fruit moth, was imported from the island of Hondo, Japan. It differs from the usual twig-larval parasite in that the females are normally thelyotokous. Males occur rarely but are apparently of no importance in reproduction. Adults are diurnal. There is no tendency to premature cocooning in overwintering material.

This parasite has been imported each year since 1933. During that year 80 adults were obtained, principally from field-collected fruit moth larvae shipped in from Japan. These were sufficient to parasitize several hundred fruit moth larvae for overwintering at Moorestown. Breeding stock was successfully overwintered and large numbers were bred during 1934 and 1935. Up to and including 1935, 22,121 adults were obtained, of which all but approximately 1,300 were obtained by breeding at Moorestown. Of this number, 19,687 were liberated, and 200 were shipped to other stations for breeding stock. The difference between production and liberation is 11 percent of production and represents chiefly stock used in breeding and mortality in transit. A relatively small proportion of the total production was sufficient to maintain breeding stock, and the mortality rate in shipments was always low. In 1935 it was 4.3 percent of the total shipped.

Most of the liberations of this species were made in 1934 and 1935. The size of the unit liberated was much increased in 1935, bringing the average for all liberations to 216. Releases were made from Connecticut to Michigan and as far south as North Carolina.

In 1935, this species was recovered in considerable numbers from four properties in New York, from twigs collected a few days after the liberation. In one of these recoveries 22 of this parasite were reared, which was 27.2 percent of the total emergence. No record of establishment has yet been obtained.

Calliephialtes laspeyresiae (Uchida)

The adult of *Calliephialtes laspeyresiae* attacks and paralyzes the prepupae of the fruit moth in the cocoon. Many of these are pulled partly out of the cocoon, bitten, and chewed, thus being killed without being oviposited upon. The egg is laid on the outside of the prepupa, and the larva feeds externally, forming its cocoon within the cocoon of the host. One parasite only completes its development on a single prepupa. It is probably always a primary parasite, as there is no evidence of attack on other parasites. The females are greatly outnumbered by the males even among parasites reared from field-collected material.

This parasite was first imported from Japan in 1933 as host-free cocoons and adults. From the material received, 134 adults were obtained, of which only 17 were females. Sixteen of these females were exposed with 350 fruit moth cocoons, and not one fruit moth escaped attack. Fifty-four parasites were produced, only 1 of which was a female. Breeding was not carried further on account of the extremely low ratio of females in the bred stock and the predacious activity of adult females on host prepupae, which reduces the stock of available hosts.

A total of 338 were obtained from all sources during 1933, 1934, and 1935. Only 12 percent of these were females. No satisfactory liberations have been made. Those imported in 1933 were used for testing the possibilities of breeding. During the last 2 years 146 were liberated, all in Burlington County, N. J., but of these only 34 were females. The 1934 release was made in April before the larvae in all overwintering cocoons had pupated, and the 1935 release was timed to coincide with the beginning of cocooning of first-brood larvae No recoveries were obtained.

Cremastus flavoorbitalis (Cameron), and others

Parasite importations from Japan in 1932 included the first shipment for this work of *Cremastus flavoorbitalis*. These parasites of twig-infesting larvae came from both Japan and Chosen, and mixed with them were numbers of two other undescribed species of *Cremastus* which could not be distinguished in the living material. *C. flavoorbitalis* has also been reared from the European corn borer (*Pyrausta nubilalis* (Hbn.)) and colonized against that pest.[7]

This species was first successfully imported as an adult, later it was obtained in shipments of fruit moth cocoons, but during 1934 and 1935 most of the adults were obtained from shipments of host-free parasite cocoons. Part of the 1932 stock was used in an attempt to

[7] Bradley, W. G., and Burgess, E. D. The biology of cremastus flavoorbitalis (cameron), an ichneumonid parasite of the european corn borer. U. S. Dept. Agr. Tech. Bull. 441, 15 pp., illus. 1934.

breed it in confinement. The parasites imported showed normal vitality, and plenty of evidence of activity on the young fruit moth larvae exposed with them. A number of larvae were dissected, and several eggs and first-instar parasite larvae were seen. A total of 6,500 host larvae were exposed, from which 1,786 host moths emerged, but not one *Cremastus*. Dissections were made of several mature, apparently normal, healthy larvae in which dead *Cremastus* larvae were found. Since 1932 no attempts have been made to breed it in confinement.

All the parasites used in liberations were obtained directly from the 580 imported from 1932 to 1935, inclusive. Females have always considerably outnumbered males, but the species has never been obtained in sufficient numbers for satisfactory releases. Eleven liberations of 520 adults were made in scattered locations from Connecticut to Michigan and south to Maryland. The difference between production and liberations was 10.3 percent of production and represented the total mortality in shipments. This indicates that the vitality of adults released was satisfactory. At the close of 1935 it had not been recovered from any of the locations where it was liberated against the fruit moth.

Elodia flavipalpis Aldrich, and others

The twig-infesting larvae of the oriental fruit moth are parasitized to a moderate extent in Japan, and less abundantly in Chosen, by three small tachinids. These have been handled without separation by species. *Elodia flavipalpis* is the most abundant, but some of *E. subfasciata* Aldrich and *Phorocera pumilio* Aldrich also occur. In the case of *Elodia*, the host is not killed until it reaches the pupal stage, and the *Elodia* puparium is formed within the host pupal remains in the host cocoon. The method of attacking the host was not observed.

These parasites were imported in 1933, 1934, and 1935. During the first two seasons the principal portion of the adults obtained were from collections of twig-infesting larvae made in Japan and shipped as host cocoons. During 1935, as a result of modifications in the technique of shipping, and in care at the receiving station, a marked increase in emergence was obtained from host-free puparia imported, so not only the total number obtained from the imported host-free material, but the total of all flies obtained was much increased over any previous year. The emergence from several importations in 1935 ranged from 22 to 55 percent of the puparia shipped.

All the tachinid parasites obtained, totaling 1,284, were reared directly from importations. Of these, 1,155 were released in 12 lots. The 10-percent difference between this and the total produced represents the mortality occurring between emergence and release, including mortality during shipment. Previous to 1935 the flies that emerged were lacking in vigor and vitality. During 1935 they not only emerged in larger numbers but were more vigorous. This was reflected in the low mortality in transit of 4.3 percent. Liberations were made in a number of widely scattered locations from Connecticut to Ohio, and south to North Carolina. Through 1935 no recoveries had been obtained. No attempt has been made to breed these species.

Eubadizon extensor (Linnaeus)

Eubadizon extensor is a parasite of twig-infesting larvae, occurring in southern Europe and in Japan. It was first imported in 1931 from Europe, when 9 adults were reared from field-collected material in a total host and parasite emergence of about 112,000. In Japan it is a more common parasite, but for several years it has been included with the similar and more abundant *Macrocentrus thoracicus* of that region.

In 1931, 6 adults from Europe were released at Moorestown, and in 1935 2 additional releases of 109 adults from Japanese material were made nearby. In addition, an undetermined number were obtained and released with *Macrocentrus thoracicus*. No recoveries have as yet been obtained. Even if obtained it would be difficult if not impossible to distinguish it from the indigenous *Eubadizon pleurale* Cresson.

Eurytoma appendigaster (Swederus)

A parasite of the cocoon stage, *Eurytoma appendigaster*, which is a native of this country, was also found to be a parasite of the fruit moth in southern Europe. Since it was found only as a primary parasite in that section, it was included in one of the importations of 1931. Twenty-two adults were shipped, but only three arrived alive. Since in this country it was known to be not only a primary parasite of the fruit moth but also a hyperparasite attacking several of its primary parasites, the stock received was at once destroyed.

The native *Eurytoma appendigaster* is one of the most abundant primary parasites of fruit moth cocoons in southern New Jersey. But it is also a common parasite of the genera *Macrocentrus* and *Glypta*. It emerges either from the pupal or the prepupal stage. Usually one adult issues from one host, but sometimes there may be two.

Gambrus stokesii Cameron

One of the principal parasites attacking the fruit moth in the vicinity of Sydney, Australia, is *Gambrus stokesii*. It attacks the pupal stage without stinging or paralyzing the host. Several eggs are usually laid loosely beside the active host in each cocoon attacked. The first larva to emerge devours the unhatched eggs and then attacks the pupa, at first as an ectoparasite. Later the developing larva enters the host pupa, within which it spins a cocoon at the termination of its larval development.

About 3,000 *Gambrus* cocoons were imported in 1932, of which an estimated 61 percent arrived alive. Although no evidence was obtained that the species was hyperparasitic in its native habitat, it was considered advisable to test it for tendencies toward secondary parasitism before releasing it from quarantine-room conditions. Experiments at Moorestown showed that it could be forced to oviposit on cocoons of *Glypta rufiscutellaris*, but cocoons of *Macrocentrus ancylivorus*, *M. pallisteri*, *Pristomerus ocellatus*, and *Ascogaster quadridentatus* exposed at the same time were not attacked. Several eggs were deposited upon *Glypta* pupae, but only 1 of these developed to an adult parasite. When *Glypta* cocoons were exposed with fruit moth cocoons, the preference for the latter was in the order of 16 to 1. These tests indicated that *Gambrus stokesii* was essentially a primary

parasite of the fruit moth that might occasionally be a secondary, but without any likelihood of preferring or increasing on any of the parasites of the fruit moth. So release in the United States was authorized.

By the time these tests had been completed the remainder of the material originally imported had succumbed after long retention in storage, and the work in Australia had been terminated. An attempt was made to increase the stock for liberation from the small amount of breeding material then on hand. Emergence from this stock soon diverged strongly to males, the excess over females being so great that it was possible merely to maintain breeding stock. During this period of breeding, from December 1932 to June 1933, over 2,600 parasite eggs were obtained, 2,400 fruit moth pupae were parasitized, and 640 *Gambrus* adults produced. Of these only 148 were females, and from the last 67 obtained only 5 were females.

Because of this difficulty encountered in breeding, the remaining stock of 91 adults (46 females) was released in June 1933 in 2 locations, the larger number at Crozet, Va. From the Moorestown liberation 1 oriental fruit moth cocoon parasitized by *G. stokesii* was recovered the week following the release. At the close of 1935 no other recoveries had been obtained.

Glypta rufiscutellaris Cresson

Glypta rufiscutellaris is a valuable parasite of twig-infesting larvae of the fruit moth over a considerable portion of the eastern half of the United States. While it has been recognized for some time as one of the principal parasites of this pest in the peach-growing counties of the Appalachian region, it had not been recovered before 1931 as a parasite of the fruit moth from numerous counties in Virginia, North Carolina, South Carolina, or Georgia.

A limited number of liberations consisting of adults reared at Moorestown from *Epiblema strenuana* have been made in Albemarle County, Va.; Moore, Richmond, and Wake Counties, N. C.; Greenville County, S. C.; and Habersham and Jackson Counties, Ga. It is now established but not important in Albemarle and Greenville Counties, but at the close of 1935 it had not been recovered from the other counties in which it was colonized.

Hemiteles areator Gravenhorst

In 1931, 47 adults and 547 cocoons of the fruit moth parasitized by *Hemiteles areator* were received from southern Europe. This insect was sent in as an undetermined species found to be a primary parasite on fruit moth cocoons in France. The material was held at Moorestown under quarantine conditions until a determination was obtained. When it was found to be a common European species frequently reared as a hyperparasite of Lepidoptera, all living material in hand was destroyed and importation discontinued.

Inareolata molestae Uchida

Among the twig-larval parasites of the fruit moth found in Japan and Chosen, the predominant species in many sections, and one widely distributed, is *Inareolata molestae*. It was first imported in small num-

bers in 1932, and in larger numbers during the succeeding years. The first shipment of adult females was successful, 70.4 percent of the females arriving alive and active. During 1933 two other small shipments of adults came through in good condition, but most of the *I. molestae* imported that year were obtained from consignments of field-collected material shipped as host cocoons. In 1934 and 1935 most of the material imported was shipped as host-free parasite cocoons. This material arrived in 17 to 18 days less time than was required for bulkier shipments of parasites in the host cocoon, and at a much more suitable period for liberation.

Breeding of this species in confinement proved moderately successful. In 1933, 8,599 out of a total handled of 17,505 were produced at Moorestown. Females have a surprising longevity, frequently remaining alive and capable of reproduction until after their progeny begin to emerge. One female imported as an adult lived 59 days after arrival and continued to reproduce for 51 days. It has been found, however, that even though mating is apparently normal, the proportion of males to females increases in stock bred through successive generations. For the whole season of 1933 the proportion of females was 32.4 percent. Another difficulty experienced in the continuous breeding of this species is the tendency of the parasite to advance to the cocoon stage in overwintering stock. All parasites in prematurely formed cocoons die before spring, and there are usually very few retarded specimens surviving after a winter of cold storage in the fruit moth at 42° F.

A total of 43,297 adult parasites were obtained from all sources. From this stock, 151 liberations of 36,058 adults were made. The difference between this and the total number is 16.7 percent of the production. It represents a considerable number used in tests on breeding, particularly for overwinter storage, stock used in mass breeding, a few sent to the Connecticut Agricultural Experiment Station for breeding there, and mortality in shipments preceding liberation. The latter is not heavy, having been 5.7 percent of the number prepared for shipment in 1935, and about the same percentage in other years. The average number of adults per liberation was 239, but in 1935 it was more than twice that number. Information recently obtained indicates that a liberation of 250 (50 percent of them females), if made when newly infested twigs are abundant, is sufficient to produce parasitization of a large portion of the larvae in the vicinity. The liberations of this species were made in important peach-growing counties widely scattered from Massachusetts to Michigan and south to Tennessee and Georgia.

This species is apparently established at Waynesboro, Va., from a liberation made in 1933. Several other recoveries have been made which may indicate establishment. A considerable number of recoveries were obtained in 1935 within a few days of liberation in localities in New York, Pennsylvania, and Virginia. In some cases the rate of parasitization by *Inareolata* in such recoveries has been as high as 72 percent of the emergence. This initial increase in the field was usually followed by disappearance from recovery collections or marked decrease after an intervening winter, so at present there is some question as to whether this species will become of value in the control of the fruit moth in the United States.

Itoplectis alternans (Gravenhorst)

Another parasite was received from southern Europe in 1931 as an undetermined species occurring rather abundantly as a primary parasite of fruit moth cocoons of that region. It was imported in parasitized fruit moth cocoons and also in the adult stage. This material was held under quarantine conditions until a determination was obtained. During this period one generation bred on native fruit moth pupae was completed, reproduction in captivity being readily obtained. The species was determined as *Itoplectis alternans;* and since the published record of this species discloses several instances in which it has been reared as a hyperparasite of Lepidoptera, it was decided to discontinue work with it, and all imported stock was destroyed.

Macrocentrus ancylivorus Rohwer

Macrocentrus ancylivorus is an indigenous parasite attacking the twig-infesting larvae of the fruit moth. The adults are crepuscular and nocturnal. The strain that has become the dominant parasite of the fruit moth in many peach-growing districts of the Eastern States seems not to have been widely distributed previous to 1929. Records of *Macrocentrus* reared from the oriental fruit moth previous to 1929 are confusing, since some refer to *Macrocentrus* sp., and all fail to distinguish clearly the four indigenous species of this genus occurring in the fruit moth. By 1929, however, *M. ancylivorus* was undoubtedly well established as a parasite of the oriental fruit moth in a number of counties in southern Connecticut, southern New Jersey, eastern Pennsylvania, Delaware, and eastern Maryland. Outside of this area it seems to have been rare or lacking as a parasite of the fruit moth.

Since 1929 the Moorestown laboratory and several State experiment stations have been rearing and distributing large numbers of this parasite. Through 1935 the Moorestown laboratory reared 168,506 *Macrocentrus ancylivorus* adults, of which 129,696 were distributed in 387 releases in all important peach-growing districts within the area infested. The Bureau assisted the agricultural experiment stations of Massachusetts, Connecticut, New York, Ohio, Indiana, and South Carolina and the State entomologist of Georgia in obtaining large additional supplies of field-collected larvae of the strawberry leaf roller and the oriental fruit moth containing this parasite for rearing and distributing in their respective States. This material was collected from the vicinity of Moorestown. A small portion of the parasites obtained have been reared from twig-infesting larvae of the fruit moth, but the greater portion were from the field-collected *Ancylis comptana.*

Liberations have been followed by surprisingly favorable results. The parasite has risen rapidly in several widely separated and important peach-growing districts from the status of nonoccurrence to that of dominance, with rates of parasitization almost or quite as high as that occurring in southern New Jersey. It is known to be established, though not yet dominant, in a number of other sections. Analysis of the recovery work since 1929 indicates that this species has been steadily increasing in abundance and in widespread distribution, with the point of relative stabilization apparently not yet attained. In figure 15 there is presented information on the status of *Macrocentrus ancylivorus* in counties in which it is known to have been released or in

which it occurred previous to release, insofar as could be determined from recovery records to and including 1935.

In 1935 it was recovered from 13 States, 46 counties, 82 towns, and 115 separate properties; or 52 percent of all counties, 51 percent of all towns, and 51 percent of all properties in which recovery surveys have been made. It is noteworthy that although this species is now established in nearly all the States in which liberations have been made, and is by far the most abundant parasite of the fruit moth in the United States, it has been recovered from only slightly more than half of the counties, localities, and properties surveyed. It is probable that in some portion of the districts where it does not now occur there are environmental conditions which will permanently prevent the estab-

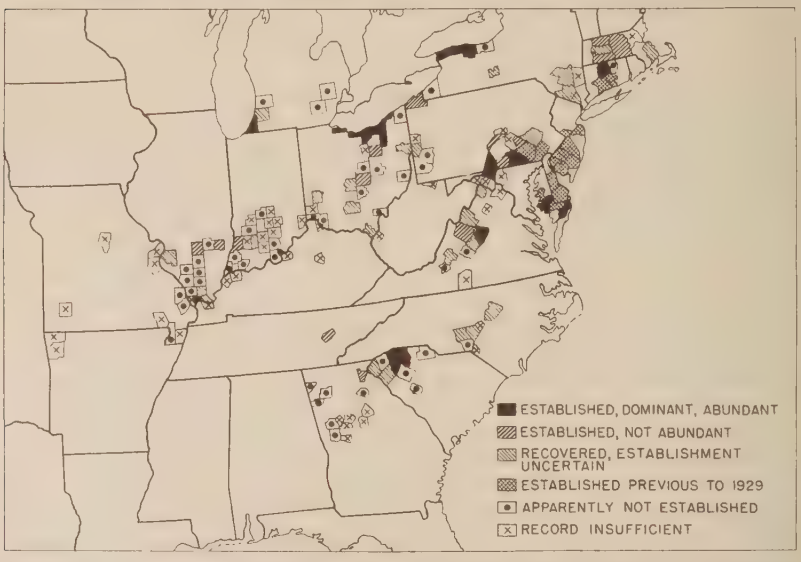

FIGURE 15.—Occurrence of *Macrocentrus ancylivorus* as a parasite of the oriental fruit moth in the United States.

lishment of this species as a valuable control factor. But it seems equally probable, particularly in those counties having 50,000 to 100,000 peach trees, in which the commercial orchards are frequently somewhat isolated, that there still are within the area infested by the fruit moth many commercial orchards in which this parasite could be successfully and profitably introduced.

MACROCENTRUS THORACICUS (NEES), AND OTHERS

A group of parasites of the twig-infesting larvae of the fruit moth present in Chosen and Japan includes *Macrocentrus thoracicus*. This parasite is most abundant in Chosen, and in that section as well as in some sections of Japan it is the second most important parasite of the fruit moth. The adult is crepuscular and nocturnal. *M. thoracicus* has been imported from the Orient and handled in admixture with *Eubadizon extensor*, since active adults of these two species are not easily separated.

Importations were received each year from 1932 to 1935, inclusive. Importations of developing parasite larvae in host cocoons, parasite adults, and parasite cocoons have all been successful, but approximately two-thirds of all the parasites obtained from importations have been reared from imported parasite cocoons. A limited amount of breeding has been done at Moorestown, but this has not proved entirely satisfactory, because, when bred in captivity, males have always greatly outnumbered females.

The total number obtained through 1935 is 18,290 adults. Of these, 14,845 were released. The difference is 18.8 percent of the total production and represents a considerable number used in propagation, some loss in propagated material held over the winter, and mortality in shipments. Adults retain their vitality remarkably well, the mortality in shipments having been 2.7 percent in 1934 and 2.9 percent in 1935.

Fifty-two liberations were made in widely separated localities from Connecticut to Michigan and south to South Carolina. The conditions under which most of these releases were made were distinctly favorable, but at the close of 1935 no recoveries had been obtained.

Orgilus longiceps Muesebeck

Orgilus longiceps, a parasite of the twig-infesting larvae, is fairly abundant in some sections of Japan. Importations were received during 1933, 1934,and 1935. It has been imported both as developing larvae within fruit moth cocoons and in the parasite cocoon stage. It has been bred in Moorestown in rather small numbers.

The total production up to and including 1935 was 3,051 adults, of which 2,613 were obtained directly from importations. Releases totaled 2,177 adults. The difference, 28.6 percent of the total produced, represents mortality in shipments and loss in out-of-season breeding and in overwinter storage. The vitality of adults at time of liberation has been good, the mortality in shipments being 10.5 percent in 1934 and 4.5 percent in 1935.

Sixteen liberations were made, all in the eastern fringe of States from Massachusetts to South Carolina. Several liberations were small and the average only 136 adults, but otherwise they were under conditions favorable to establishment. The first recoveries were were obtained in 1935 from near where 22 females had been released at Williamson, N. Y., 7 days previously. One *Orgilus* was reared from each of two small recovery collections.

Perisierola angulata Muesebeck

Perisierola angulata is a primary parasite of the cocoon stage of the fruit moth found by R. W. Burrell in the vicinity of Sydney, Australia, in 1930. The adults are small bethylid wasps distinguished from the more common hymenopterous parasites of the fruit moth by their strong thigmotropism and their antlike agility. Females cut through the cocoon wall; enter and paralyze the prepupa by stinging, and deposit one to several eggs on the host. They also bite and feed on the blood of the prepupae, thus destroying large numbers upon which no eggs are deposited. The larva is an ectoparasite, completing its development outside the host and spinning its cocoon beside the remains of the prepupa. One to several adults

emerge from each host cocoon. The entire life cycle is very short, being less by several days than that of the host. No stage of the parasite can be held for any great length of time in cold storage at 40° F. The lack of any apparent pause in development indicates that it breeds continuously throughout the year. If so, it will probably succeed only in the warmer sections where occasional warm winter days will permit adult activity. For no accountable reason reproduction under incubator conditions diminished rapidly in midwinter so that breeding stock decreased from large numbers to a few remaining females, and then started increasing once more until the normal rate was attained.

Several thousand parasite cocoons were produced in Australia and shipped to Moorestown in 1931. From them 1,578 adults were reared and used to start breeding which was continued at Moorestown until the fall of 1933. Breeding stock was furnished the Connecticut Agricultural Experiment Station, where breeding for distribution within that State has been continued.

A total of 34,403 adults were obtained from importation and breeding, of which 32,825 were bred at Moorestown. The total released was 25,600. The difference, 25.6 percent, represents considerable unavoidable loss because of the necessity of out-of-season rearing to maintain breeding stock, adults used in propagation, mortality in shipments, and breeding stock shipped from the laboratory. The mortality in shipments was only 3.4 percent.

Seventy-six liberations were made from Moorestown, distributed in nearly all the Atlantic States from Massachusetts to South Carolina, and also in Tennessee, Kentucky, Ohio, Indiana, and Illinois. Most of these liberations have been satisfactory as to the number and vigor of the parasites released and the host status at the point of release. It is considered that the species will have a much better chance for establishment in the southern portion of the area covered by these liberations. It was recovered in 1932, subsequent to liberations made in the same season, in Rockland County, N. Y., Burlington County, N. J., Sussex County, Del., and Henderson County, Ky. From 1932 to 1935 no recovery work was done except in Burlington County, N. J., where it has not been recovered since 1932.

Perisierola, new species

A new species of *Perisierola* from Japan, a primary parasite of the fruit moth prepupa in the cocoon, has many of the characteristics of *P. angulata*. It is reported by R. W. Burrell, who has worked with both species, to be much more difficult to breed than the Australian species. It was first imported in 1935, when 1,587 adults and parasite cocoons were received in good condition. Three colonies totaling 1,132 were released late in the fall in Wicomico County, Md. The remaining 455 were used in tests of production and in an attempt to carry adults through the winter in cold storage, both of which were unsuccessful.

Phaeogenes haeussleri (Uchida)

Another primary parasite of fruit moth cocoons abundant in Japan is *Phaeogenes haeussleri*. Cage tests made in this country and in Japan indicate that it can be bred readily in captivity on fruit moth

cocoons, but that it consistently refused to attack cocoons of primary parasites of the fruit moth including *Glypta*, *Cremastus*, *Pristomerus*, *Macrocentrus*, *Orgilus*, *Inareolata*, *Bassus*, and *Phanerotoma*. P. *haeussleri* is an internal parasite of the pupal stage. It apparently overwinters as an adult, females collected in the fall being readily carried through the winter in cold storage at 42° F. The females are long-lived, in breeding work frequently remaining alive and productive long after their progeny have begun to emerge. Development is very rapid, a life cycle being completed in about 14 days at 80°, or slightly more than half the time required for a cycle of the host. Unlike most fruit moth parasites, these display strong thigmotropism and negative phototropism, and for this reason are rather difficult to handle.

Phaeogenes haeussleri was imported in 1933, 1934, and 1935. Most of the material imported consisted of adult females collected in the fall from sweetpotato foliage in Japan. A few were obtained from importations of cocoons. The total number obtained was 4,185 adults, of which only 151 were bred at Moorestown. Only enough breeding was done here to indicate the feasibility of propagation; 4,172 adults were liberated. There was practically no mortality in shipments.

Six liberations were made in New Jersey, Maryland, and North Carolina. The largest releases have been of overwintering adult parasites at the time of pupation of the overwintering fruit moth. Smaller numbers have been held in storage until the beginning of first-brood fruit moth pupation and then released. Previous to the end of 1935, attempts at recovery had been made only in Burlington County, N. J., and here none was recovered.

Phanerotoma grapholithae Muesebeck

Phanerotoma grapholithae is a fairly abundant parasite of the fruit moth larvae in Japan. It occurs less abundantly in Chosen. It oviposits in the egg, and the adult parasite emerges from the cocoon of the host. It is usually more abundant in the fruit-infesting larvae late in the summer than in the larvae of earlier twig-infesting broods. It overwinters as a partly developed larva within hibernating host prepupae and shows no tendency toward unseasonal issuance from the overwintering fruit moth host.

Importations of this species were received in 1933, 1934, and 1935. A majority of the parasites obtained were reared from host cocoons of larvae from eggs parasitized in Japan, and from the shipment of parasite cocoons. Mass breeding at Moorestown has been quite successful. The total number obtained was 25,658, of which 24,756 were bred at Moorestown. Releases of 20,592 adults were made, which is 80.3 percent of the total produced. A considerable portion of the balance was used for propagation. There was some loss in overwintered breeding stock. The mortality in shipments was 7.2 percent of the number shipped.

One hundred and thirty-one liberations were made. These were distributed in all the Atlantic States from Massachusetts to Georgia, and in Tennessee and Indiana. Many of these liberations were of about 100 adults, a few approximately 400, the average being 157. There had been to the close of 1935 only 1 recovery of this parasite. It was obtained from a collection made at Moorestown and evidently resulted from adults released shortly before the collection was made.

Plectochorus iwatensis (Uchida)

What is reported to be a secondary parasite of Lepidoptera, *Plectochorus iwatensis*, has been reared in small numbers from parasite cocoons imported from Japan, and in smaller numbers from consignments of host cocoons containing parasites. In 1935, 28 were reared from consignments totaling 31,384 parasites. All emerging parasites of this species were destroyed.

Pristomerus ocellatus Cushman

Pristomerus ocellatus is a native parasite of the twig-infesting larvae. It has a wide distribution in the infested section of the United States, and is occasionally the dominant parasite in some locations. It also occurs in abundance as a parasite of *Epiblema strenuana*.

In 1931, 4 liberations were made of these parasites, obtained from the ragweed borer, in localities in which the species was not known to occur as a parasite of the fruit moth. From 2 of these it was not recovered previous to the end of 1935. At Kingston and at Harriman in Roane County, Tenn., however, it has been recovered each year, the parasitization by this species in Roane County for 1933 being 2.2 percent of the total emergence of 587 obtained from recovery collections. This degree of parasitization is not important and may not be the result of the liberations, but in 1930, before the liberation, no individuals of *Pristomerus ocellatus* were reared from 190 emergences obtained in the same section.

Pristomerus vulnerator (Panzer)

Pristomerus vulnerator was found to be a parasite of twig-infesting larvae of the oriental fruit moth in southern Europe, and also in Japan and Chosen. It was imported from Europe in 1930 and 1931. Part of the material received from that source was reared from *Anarsia lineatella* and was imported as parasite cocoons. The remainder was reared from fruit moth larvae collected in Europe and imported as host cocoons. Attempts to breed it at Moorestown have been unsuccessful. The total number of parasites obtained during these 2 years was 2,111, of which 1,950, or 92.4 percent of the number produced, were liberated. The difference of 7.6 percent represents stock used in breeding tests and mortality in shipments. Liberations were made in Rockland County, N. Y., Burlington County, N. J., and Roane County, Tenn. Several specimens were recovered in 1932 from locations in Moorestown in which liberations had been made the same season. Several more were recovered the following season from *Anarsia lineatella*, but none subsequently to the end of 1935.

This species was imported from Japan and Chosen during 1933, 1934, and 1935. The Japanese material was obtained from the oriental fruit moth. It was received largely in the parasite-cocoon stage. A few have been reared from imported host cocoons. A total of 1,021 were obtained from Japanese shipments, of which 956, or 93.6 percent, were liberated. The mortality in shipments for colonization, 2.8 percent, is very low. Releases were made in 12 locations in Connecticut, New York, New Jersey, Pennsylvania, Maryland, Ohio, and Michigan. Many of these were of less than 100 adults, slowly accumulated from scattering emergence, and unsatisfactorily small. There

had been to the end of 1935 only 1 recovery from liberations of material from Japan. This was made in 1935, from a collection at Williamson, N. Y., 7 days after the release of 67 adults (51 females). There were 66 emergences, 2 of which were adults of *Pristomerus vulnerator*.

Trichogramma euproctidis (Girault)

The egg parasite *Trichogramma euproctidis*, which attacks and emerges from the egg, was found in southern Europe. It was imported in 1931 when a total of 640 parasitized eggs were received. It was found possible to propagate it by breeding it on the eggs of the common bagworm, and during 1932, 1,126,000 were produced at Moorestown. A total of 570,300, or 50.6 percent of the production, were liberated. In order to maintain vigorous stock, continuous breeding was carried on, and this resulted in the production of large numbers of parasites during periods unfavorable for colonization.

Thirteen liberations averaging 43,869 parasites each were made over the area, which included several Atlantic States from Massachusetts to Georgia, and also Tennessee, Ohio, and Illinois. The releases were in the form of larvae and pupae within the host egg. Each lot was separated into several units enclosed in small antproof cages which were suspended from trees at several widely separated points in the orchards receiving the liberations. Recovery work on this species requires a special laborious and expensive technique. Very little such work has been done, so it is not known whether or not this species is established.

Trichogramma minutum Riley

An indigenous parasite (*Trichogramma minutum*) which attacks and emerges from the egg is in some locations of considerable importance in the control of the fruit moth, though experiments at Moorestown indicate that mass liberations are of little value in reducing fruit infestation.[8] It was found also to occur as a parasite of the fruit moth in Japan, and in 1933, 1,580 host eggs parasitized by this species were imported. In the imported strain the adults were black, in marked contrast to the strain of lemon-yellow adults commonly reared from the fruit moth in New Jersey. The imported strain was received too late in 1933 to breed for colonization that season. An attempt was made to carry it over until 1934 by continuous breeding on bagworm eggs, following the technique used successfully with the American strain and with *T. euproctidis*. For some undetermined reason bagworm eggs proved unsatisfactory for breeding this strain, and the breeding stock was lost before fruit moth eggs became available in 1934.

Trichomma enecator (Rossi)

A parasite of twig-infesting larvae of the fruit moth in France and Italy (*Trichomma enecator*) was reared in small numbers from field-collected larvae imported as host cocoons. In 1931, 214 adult parasites were obtained, of which 205 (95.8 percent) were liberated.

[8] Allen, H. W., and Warren, A. J. The results from two years' experiments in mass liberations of Trichogramma minutum against the oriental fruit moth. Jour. Econ. Ent. 25: 374–380, illus. 1932.

No attempt has been made to propagate by mass breeding. Two liberations were made, both at Moorestown, but no recoveries have been obtained.

Zenillia roseanae Brauer and Bergenstamm, and others

Relatively small numbers of Tachinidae have been reared from twig-infesting larvae of the oriental fruit moth in France and Italy. Three species not readily separated in the active adult stage have been received, reared, and liberated without separation. The most abundant of these has been *Zenillia roseanae*. The other species which have been included are *Actia tibialis* Robineau Desvoidy and *Arrhinomyia tragica* (Meigen).

A total of 124 adults were obtained, of which 110 were reared from oriental fruit moth larvae collected in Europe and imported as host cocoons, and the remainder from puparia shipped. No breeding has been attempted. Ninety-two, or 74.2 percent, of those obtained were released. Three liberations were made at Moorestown. The stock liberated lacked vigor and vitality, and the numbers released were unsatisfactorily small. Up to the end of 1935 none had been recovered.

SUMMARY

There is presented in this circular an account of the work of the Bureau of Entomology and Plant Quarantine from 1929 to 1935, inclusive, in importing, breeding and rearing, and distributing parasites of the oriental fruit moth.

Seven beneficial species of the parasites of the oriental fruit moth found in Europe, 2 of the 10 species found in Australia, and 17 of about 65 species found in Japan and Chosen were imported. The technique of importing has been developed to provide large numbers of the desired species of a high degree of vitality and vigor at a period suitable for liberation, and to prevent any possibility of the accidental introduction of undesirable host insects or hyperparasites. During this period 47 separate lots were imported. These contained 428,292 host-insect cocoons containing parasites, 79,155 parasite cocoons, and 8,818 parasite adults. From these a total of 64,815 adult parasites suitable for release were obtained.

The parasites obtained directly from importations were supplemented by extensive breeding and rearing at the Moorestown, N. J., laboratory. One of the most important phases of this work has been the production of large numbers of the indigenous *Macrocentrus ancylivorus* and its colonization throughout the area infested by the fruit moth. Methods were also developed whereby large additional supplies of the imported species have been bred for release. The principal imported species which were bred for release are *Bassus diversus*, *Inareolata molestae*, *Trichogramma euproctidis*, *Phanerotoma grapholithae*, *Ascogaster quadridentatus*, and *Perisierola angulata*.

The total number of useful parasites obtained, including those obtained directly from importations, those bred at the Moorestown laboratory, and those reared from field-collected material were 390,805 of the larger species that issue from the cocoon and 1,126,000 of the much smaller egg parasite, *Trichogramma euproctidis*. Of these 308,414 of the first mentioned group and 570,300 *Trichogramma*

were released. Since many of the releases were made in districts several hundred miles from the Moorestown laboratory, special attention was given to the methods of shipping the parasites. Iced shipping tubs forwarded by railway express proved satisfactory for transit periods up to 60 hours, and unrefrigerated packages forwarded by air express were satisfactory where transit could be completed within 30 hours.

Each of the 1,093 separate liberations made is listed as to State, county, and town in which the release was made and the number released in each colony. The species of parasites released in each county are presented in a separate list. The circular concludes with a brief discussion, for each of the species of parasites handled, of available information pertaining to importing, breeding or rearing, and shipping for release.

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